

A CONTRIBUTION TO THE
HYDROBIOLOGY OF THE WESTERN CAPE PROVINCE,

I

HYDROBIOLOGICAL STUDIES ON THE GREAT BERG
RIVER, WESTERN CAPE PROVINCE,

PARTS 1, 2, AND 4.

PRESENTED AS A THESIS FOR THE DEGREE OF PH.D.

IN THE UNIVERSITY OF CAPE TOWN

BY

A. D. HARRISON, M.Sc.

MAY 1958.

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.



HYDROBIOLOGICAL STUDIES ON THE GREAT BERG RIVER, WESTERN CAPE PROVINCE

PART I

General Description, Chemical Studies and Main Features of the Flora and Fauna

By A. D. HARRISON and J. F. ELSWORTH*

National Chemical Research Laboratory, Pretoria

SUMMARY

This is the first of a series of papers on the ecology of the Great Berg River in the Western Cape Province, South Africa. The topography and the flora are dealt with shortly and the physical and chemical conditions are described in some detail. The fauna is described broadly and related to the physical zonation of the river; the part played by the physical conditions in the zonation of the fauna is discussed and conditions are compared with those found in other parts of the world.

CONTENTS

	PAGE		PAGE
INTRODUCTION	125	3. Composition of the faunas of the main biotopes	176
ACKNOWLEDGEMENTS	127	(a) Stones in current	176
A. METHODS	128	(b) Cascades	185
B. GENERAL DESCRIPTION OF THE GREAT BERG RIVER	133	(c) Stony backwaters	186
Sampling Stations	137	(d) Soft bottoms	192
C. ZONATION OF THE RIVER	138	(i) Sandy bottoms	192
D. PHYSICAL AND CHEMICAL CONDITIONS	142	(ii) Muddy bottoms	196
1. Flow	142	(e) Marginal vegetation	199
Current speeds	145	(f) Bottom vegetation	208
2. Temperatures	146	G. QUANTITATIVE STUDIES ON FAUNA	210
3. Water Analyses	148	1. Stones in current	210
Summary	166	2. Muddy bottoms	214
E. MAIN FLORISTIC FEATURES	166	H. MAIN ZONAL FEATURES OF THE FAUNA—A SUMMARY	215
F. THE FAUNA	169	I. NOTE ON THE FISH FAUNA	217
1. General remarks	169	J. DISCUSSION	218
2. Distribution of the main groups	170		

INTRODUCTION

Apart from its mineral wealth, South Africa is a country poor in natural resources. Its agricultural development has always been hampered by lack of water, and short-sighted farming practices have led to the destruction of river catchments, erosion of

*The work was carried out in the Departments of Zoology and Chemistry, University of Cape Town.

The following systematists assisted with identification of material:

Members of the staff of the Bolus Herbarium and Botany Department, University of Cape Town, especially Miss E. Esterhuizen (higher plants) and Mr. S. Garside (mosses).

Sphaeridae—Mr. J. G. J. Kuiper.
 Polychaeta—Professor J. H. Day, Cape Town.
 Ephemeroptera—Mr. R. S. Crass, Pietermaritzburg.
 Heteroptera—Mr. I. Lansbury, British Museum.
 Hydracarina—Dr. K. Viets, Bremen.
 Veliidae—Dr. L. Hoberlandt, Prague.
 Trichoptera—Dr. K. M. F. Scott, Cape Town.
 Dytiscidae—Mrs. J. Omer-Cooper, Grahamstown.
 Gyrinidae—Dr. P. Brinck, Lund.
 Curculionidae—Sir Guy Marshall, British Museum.
 Tipulidae—Dr. H. G. Wood, Cape Town.
 Culicidae—Mr. I. Muspratt, Johannesburg.
 Chironomidae—Dr. P. Freeman, British Museum.
 Dixidae—Dr. P. Freeman, British Museum.
 Ceratopogonidae—Dr. B. de Meillon, Johannesburg.
 Leptidae—Mr. B. Stuckenburg, Natal Museum.

The following are working on material:

Oligochaeta—Dr. A. J. Cain, Oxford.
 Cladocera—Dr. J. P. Harding, British Museum.
 Copepoda—Dr. J. P. Harding, British Museum.
 Ostracoda—Dr. H. W. Schäfer.
 Hydrophyllidae—Mr. J. Balfour-Browne, British Museum.
 Hydraenidae—Mr. J. Balfour-Browne, British Museum.
 Dryopidae—Dr. H. E. Hinton, Bristol.
 Helmidae—Dr. H. E. Hinton, Bristol.
 Helodidae (larvae)—Dr. H. Bertrand, Paris.

The work was financed by the South African Council for Scientific and Industrial Research, and laboratory space and facilities were provided by the Zoology Department, University of Cape Town.

A. METHODS

The main survey was carried out by one zoologist (A. D. Harrison) and one water chemist (J. F. Elsworth). Higher aquatic plants, of which there were few types, were studied, but algae, unfortunately, had to be largely neglected. These are now being studied by Dr. B. J. Cholnoky. Field readings and water samples were taken at regular monthly intervals at a series of stations covering nearly all regions of the river. Biological observations were based on monthly samples of bottom fauna taken at the same stations and from what were considered to be the main biological niches or biotopes. A limitation was placed on the organisms collected as all nets used in the main survey were of silk grit gauze of 23 meshes per inch.

1. PROCEDURE FOR STUDIES OF BOTTOM FAUNA

Apparatus

After an initial survey to determine what habitat types occurred in the course of the river, a number of sampling devices were tested. The following were found to be most suitable and were subsequently used throughout the survey:

- (a) Hand-net with circular brass frame of $\frac{1}{2}$ in. by $\frac{1}{8}$ in. brass attached to a broom-handle. Diameter of frame 10 in.
- (b) Hand-net made from the same material as above but with frame in the form of an equilateral triangle of 10 in. base.
- (c) Rectangular tow dredge. Frame 14 in. by 5 in. opening of strip brass $2\frac{1}{2}$ in. by $\frac{1}{4}$ in.
- (d) Surbur square foot, stream bottom sampler, as described by Davis (4).
- (e) Birge-Ekman grab, Lenz modification (225 sq. cm.) (6).

The netting used in items (a) to (d) was of silk grit gauze with a mesh of 23 to the inch, attached to the frames by canvas strips.

Types of bottom sampled

1. Stony Bottom.
 - (i) In current—Surbur sampler or hand-nets (a) and (b).
 - (ii) In torrent—hand-nets (a) and (b).
 - (iii) In backwater or pool—hand-nets.
2. Sandy Bottom. Birge-Ekman grab in fine sand, hand-nets, dredge.
3. Muddy bottom. Birge-Ekman grab, hand-nets.
4. Marginal vegetation. Hand-net (a).
5. Stream bottom vegetation. Hand-net (a).

The Surbur sampler and the Birge-Ekman grab were used according to the standard procedure laid down in the papers referred to. When the hand-net was used the substratum was disturbed violently and all disturbed matter caught in the net. In the case of marginal vegetation the net was swept through as rapidly and as violently as possible.

Quantitative samples were taken from stony bottoms in the current and from muddy bottoms and from some sandy bottoms. No attempts were made to take quantitative samples from marginal vegetation, as the only possible method is laborious and uncertain.

Samples from both the stony and sandy river-bed were taken only from those portions which were permanently submerged, or, at least, had been for over a month prior to the sampling. This precaution was important in autumn and early winter when the general water-level was rising.

Treatment of Samples

Field samples were bottled in river water on the spot and a waterproof label added bearing all particulars. A few cc. of 40% formalin were added on the spot or in the laboratory on the same day. The samples were sorted in the laboratory and the animals classified to species as far as possible and then counted.

2. PROCEDURE FOR CHEMICAL AND PHYSICAL STUDIES ON THE WATER

Sampling

Samples were taken in accordance with methods adopted by the Water Research Division of the National Chemical Research Laboratory and detailed in the standard specifications of the South African Bureau of Standards (7).

Analysis

At the time of sampling the following field tests were carried out:

- (a) *pH*. A Lovibond comparator was used with the usual colorimetric indicators covering the range from pH 3.8 to 8.4. Determinations were sometimes checked with a Beckman pH meter, particularly in cases of discrepancies which were sometimes noted when two different indicators were used to test one sample. For the last fifteen months of the survey the Beckman meter was used exclusively.
- (b) *Temperature*. An ordinary thermometer was used and was usually held in running water. During dry months the temperatures of still pools and running water were recorded separately, and on a few occasions temperatures were measured at different levels in deep pools by bringing up water samples in bottles from different depths.
- (c) *Flow measurements*. A Stevens Midget Current Meter was used. Readings were taken in different parts of the stream, pools, rapids, etc.
- (d) *Conductivity*. Measurements were made with a Dionic water tester reading in micromhos.
- (e) *Dissolved oxygen*. Until October 1951, the samples were collected in 500 ml. bottles filled with CO₂ gas. Though satisfactory, there was a risk of spoiling the sample should the bottle be incompletely filled with gas; therefore, subsequently, the displacement method was used which involved using a large bottle connected to the displacement tube of the sampling bottle so that a large amount of water flowed through. When samples were collected in slow-running or still water on a warm day, the temperature of the actual sample was read as temperature gradients were found to be considerable, sometimes as much as 2° C. per foot. All samples were taken in duplicate.

The Rideal-Stewart modification (1) of Winkler's method was used for determining dissolved oxygen. The oxygen was 'fixed' in the field, but the duplicate sample was left untreated and used for the five-day Biological Oxygen Demand test. The barometric pressure was read from a pocket aneroid and the percentage saturation of dissolved oxygen read from a nomogram (10).

For the complete analysis in the laboratory, a winchester quart of the water was collected. Biochemical determinations were carried out as soon as possible after sampling (within 24 to 48 hours).

The following analyses were carried out:

	<i>Reference</i>
1. Free and saline ammonia nitrogen	(7)
2. Albuminoid ammonia nitrogen	(7)
3. Nitrite nitrogen	(7)
4. Nitrate nitrogen	(9)
5. Chloride	(7)
6. Sulphate	(1, 11)
7. Silica	(7)
8. Calcium	(5, 2, 3)
9. Magnesium	(5, 2, 3)
10. Total Hardness	(5, 2, 3)
11. Alkalinity	(7)
12. Turbidity—Hellige Turbidimeter	
13. Colour, true and apparent	(8)
14. Iron	(7)
15. Phosphate	(7) modified
16. Manganese	(7)
17. Total dissolved solids	(7)
18. 4-hour Oxygen absorption from KMnO_4	(7)
19. 3-minute Oxygen absorption from KMnO_4	(7)

3. METHOD REFERENCES

1. Betz, H., *Ind. Eng. Chem. (Anal.)*, 1947, 9, 543.
2. Betz, J. D., and Holl, C. A., *J.A.W.W.A.*, 1950, 42, 40.
3. Connors, J. J., *J.A.W.W.A.*, 1950, 42, 33.
4. Davis, H. S., 'Instructions for conducting stream and lake surveys'. U.S. Department of Commerce, Bureau of Fisheries Circular No. 26.
5. Diehl, H., Goetz, C. A., and Hach, C. C., *J.A.W.W.A.*, 1950, 42, 40.
6. Lenz, Fr., 'Zur Methodik der quantitativen Bodenfauna-Untersuchung. Der Stockhalter, ein neues Hilfsgerät zum Bodengreifer'. 1932. *Archiv. für Hydrobiologie*, 23, 395.
7. South African Bureau of Standards. Methods of chemical analysis. The phosphate method was modified to eliminate nitrates and silica which interfere with the reaction. Also estimations were spectrophotometric and not against standards.
8. *Standard methods for the examination of water and sewage*, 9th edition, 1946, 60. American Publ. Health Assoc., New York.
9. Taras, M. J., 'Phenoldisulphonic acid method of determining nitrate in water'. *Anal. Chem.*, 1950, 22, 1020.
10. Welch, P. S., 'Limnological methods', p. 366, Rawson Nomogram.
11. Zahn, V., *Ind. Eng. Chem. (Anal.)*, 1947, 9, 543.

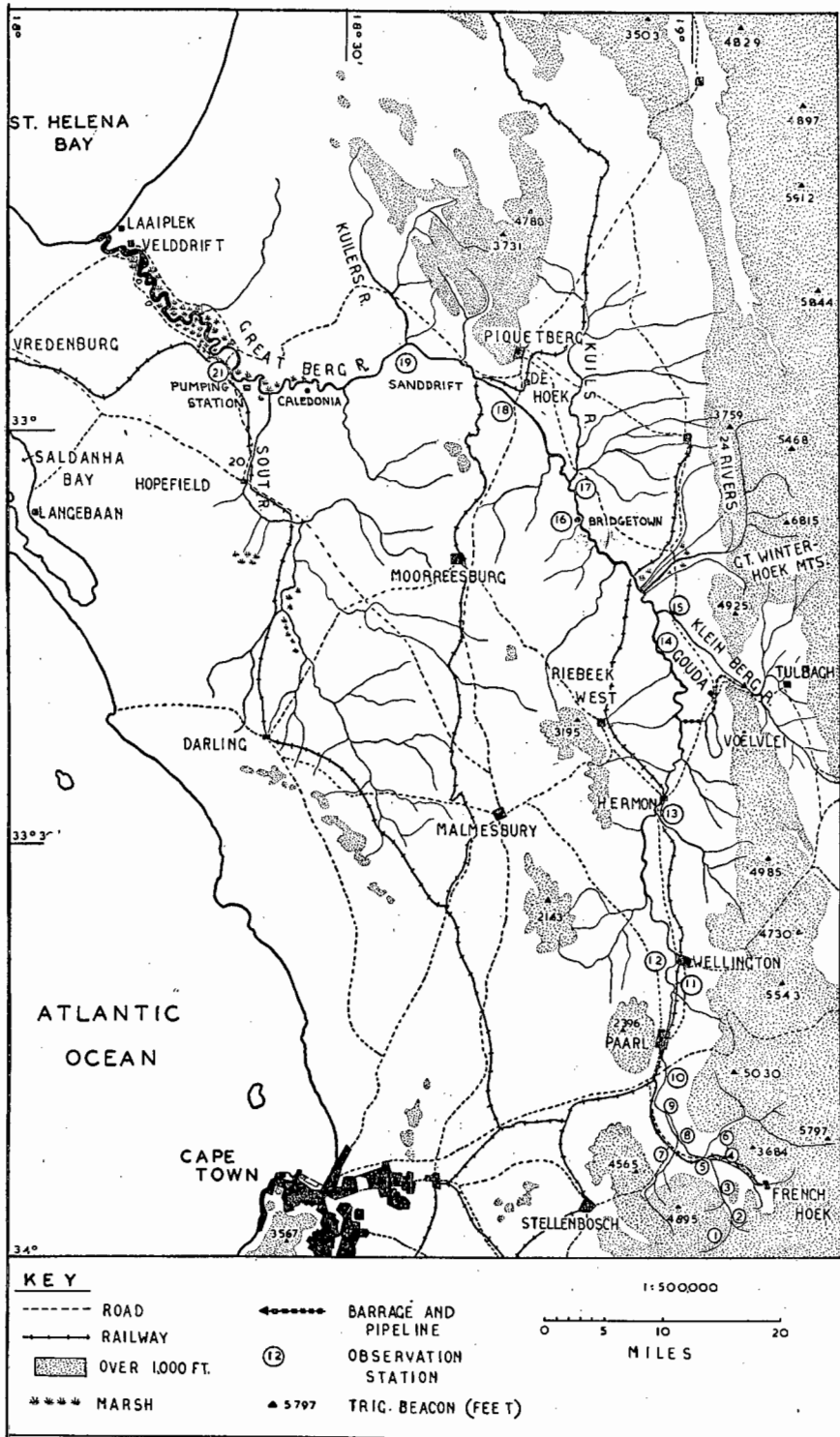


FIG. 1. The Great Berg River and tributaries. The stations used in the survey are indicated.

B. GENERAL DESCRIPTION OF THE GREAT BERG RIVER

(See Maps—Figures 1 and 2)

The Great Berg River rises in the Franschhoek mountains about 35 to 40 miles east of Cape Town and, after flowing north past the towns of Paarl and Wellington and the village of Hermon, swings west in a rough arc, past Gouda, Piketberg and Hopefield, to enter the Atlantic Ocean at St. Helena Bay, about 80 miles north of Cape Town.

If one takes the stream from the Franschhoek Forest Reserve as the main river, the main tributaries are the Franschhoek Stream, the Wemmer, the Dwars, the Kompagnels near Hermon, the Klein Berg, the 'Twenty-four Rivers', the Kuils, the Kuilers and the Sout. Those contributing most water are the Wemmer, the Dwars, the Klein Berg and the 'Twenty-four Rivers'. The Kompagnels, the Kuils and the Sout dry up in summer when the flow in the other tributaries is very low, except in the Wemmer which has an exceptionally good catchment.

The main stream and principal tributaries find their sources in steep mountain ranges which rise from 4,000 to 6,000 feet above sea-level. The peaks and most of the mountain catchments are composed of quartzitic Table Mountain sandstone, the lowest member of the Cape System, and both surface and ground waters come from this formation. After leaving the mountains, the river by-passes these resistant rocks which form outliers of high ground, such as Riebeeck Kasteel (near Riebeeck West on fig. 1). Another rock type skirted by the river is the granite mass of Paarl Mountain which is intrusive into Malmesbury beds but older than the Table Mountain sandstone.

In the Paarl area the river receives a few small tributaries from granite hills and, during the rainy season, some run-off from clayey granite soils of the foothills and lower valleys of the mountain ranges. Near Franschhoek there is some run-off from French Hoek Bed formations.

From its mountain sources, the river descends rapidly to the neighbourhood of Wellington over a bed of stones, pebbles and quartzitic sand derived mainly from Table Mountain sandstone, but here Malmesbury Series rocks protrude into the bed. From a few miles below the town, the river makes its way over a sandy bed across a somewhat hilly plain with soils derived mainly from the Malmesbury Series. This is a dominantly argillaceous group of rocks that has been recently subdivided by the Geological Survey into two parts, viz. an older division, the Malmesbury Series of late Archaean age, and a younger division of late pre-Cambrian age which has been correlated with the Loskop and Matsap series of the Transvaal.

Most of the run-off from the Malmesbury Series comes down the Kuils and the Sout, though, of course, there are numerous smaller watercourses in this region which contribute water during rain.

In the neighbourhood of the farm Caledonia, some twenty miles overland from the sea, the level of the river-bed begins to approach that of mean sea-level, after which the river meanders slowly to its mouth across a small flood plain consisting mainly of superficial coastal deposits of windblown sand, gravels, and surface limestones.

Since this study was carried out, construction has been started on a reservoir on the Wemmer which will supplement the water supply of the City of Cape Town and adjacent towns and will also help to control the flow in the river.

WATER TYPES OCCURRING IN THE RIVER

As far as the classification of water types is concerned the authors are indebted to Allen (1951) for the following divisions and definitions. The figures for depth are not Allen's, but compare roughly with his.

Pools: 'Water of considerable depth for the size of the stream, current generally slight and the flow smooth apart from small turbulent areas at the head of some pools.' Current speed—under one foot per second; depth—over eighteen inches. Smaller, sheltered parts of the stream, out of the main current, have been referred to as backwaters.

Flats: 'Water of slight to moderate current and generally smooth flow, but of less depth than pools.' Current—under one foot per second; depth—under eighteen inches. Very little sampling was done from these sections, the faunas of which were very similar to those of the shallow backwaters.

Runs: 'Water of moderate to rapid current and fairly deep, flow usually turbulent. In such places the stream is usually of less than average width.' Current—over one foot per second; depth—over one foot, runs in sandy areas are shallower. These usually graded into the next type.

Stickle: 'Shallow water with a rapid current and usually broken flow. Such conditions are often described as "ripples", "rapids" or "riffles".' Current—over one foot per second; depth—under one foot. The same portion of the river might be a run in the wet season and a stickle in the dry.

Cascades: 'Water in which a steep gradient, combined with a bed of stones or rocks large in proportion to the size of the stream, produces a very irregular rapid flow, often with some white water.' Cascades and small waterfalls only occurred where streams were running down mountain slopes and valleys. Here current speeds were over 2.5 feet per second, and depth very variable but usually between four and eighteen inches.

The stretches of the river to which the above classification did not apply were those at Gouda and at Kersefontein where the river was deep and canal-like.

The following types of bottom were sampled for fauna:

Stony bottoms—in runs, stickles, backwaters and cascades.

Sandy bottoms—backwaters, flats and pools.

Muddy bottoms—pools and canal-like stretches.

Marginal vegetation—lining runs, stickles, pools, backwaters, and canal-like stretches.

Submerged aquatic vegetation—runs and stickles.

SAMPLING STATIONS AND DETAILS (see maps)

Station number	Locality	Types of substratum sampled for fauna
1	Franschhoek Forest Reserve, one mile above Assegaibos.	Stony bottom in stickles and runs (Q). Stony bottom in cascades. Stony bottom in backwaters. Marginal vegetation (palmiet).
2	Assegaibos stream (Trib.).	Stony bottom in stickle. (Discontinued in August 1951.)
3	Lower Forest Reserve, Driefontein bridge.	Stony bottom in stickle (Q). Stony bottom in backwater. Marginal vegetation (palmiet). Aquatic vegetation (<i>Scirpus digitatus</i>).
4	Franschhoek Stream (Trib.) Bridge at La Motte.	Stony bottom in stickle.
5	Main river, railway bridge above Groot Drakenstein.	Stony bottom in stickle and run (Q). Stony bottom in backwater. Marginal vegetation (palmiet). Aquatic vegetation (occasionally).
6	Wemmer River (Trib.) road bridge.	Stony bottom in stickle.
7	Dwars River, Franschhoek road bridge, Groot Drakenstein.	Stony bottom in stickle.
8	Dwars/Berg junction pool.	Station not used after first visit as similar to Station 9.
9	Farm, Watergat, Simondium.	Stony bottom in stickles and runs (Q). Stony bottom in backwater. Marginal vegetation (palmiet). Sandy bottom of deep pool (occasional).
10	Cecilia's Drift, National Road bridge above Paarl.	Stony bottom in stickles and runs (Q). Stony bottom in backwater. Marginal vegetation.
11	Daljosaphat, near Paarl sewage works.	Stones in stickles and runs when present (Q). Marginal vegetation. Sandy bottom of backwater.
12	Wellington, Lady Lock bridge.	Stony bottom in stickles and runs (Q). Marginal vegetation (mainly palmiet). Sandy bottom of pool or backwater (Q).
13	Hermon, road bridge.	Sandy bottom of pool or backwater. Muddy bottom of pool. Marginal vegetation (mixed).
14	Gouda, road bridge.	Mud and mixed mud and sand bottom (Q). Marginal vegetation (mainly palmiet).
15	Klein Berg River (Trib.) road bridge.	Marginal vegetation (mixed).

Q: quantitative samples.

Trib.: tributary.

Station number	Locality	Types of substratum sampled for fauna
16	Farm, Bridgetown or De Pont.	Sandy bottom in backwater. Marginal vegetation (mixed).
17	Kuils River (Trib.) at ford.	Stony bottom in stickle (no flow during dry season).
18	Piketberg, National Road bridge.	Stony bottom in stickles and runs (Q). Sandy bottom of pool (Q). Marginal vegetation (mixed).
19	Farm, Sanddrift.	Sandy bottom in quiet water. Marginal vegetation (mixed).
20	Sout River, Hopefield (Trib.).	Marginal vegetation (mixed) (no flow in dry months).
21	Farm, Kersefontein, near Berg River Station.	Muddy and mixed mud and sand bottoms (Q). Marginal vegetation (mixed).

Q: quantitative samples. Trib.: tributary.

During the first year of the survey (May 1950 to May 1951) the work was mainly exploratory and limited to the upper part of the river, stations 1 to 5. Visits were made to most of the stations twice a month but, as methods were being tested, records were incomplete. Work was extended to the whole river in May 1951; stations were then visited once a month except those on the tributaries which were sampled every two months.

C. ZONATION OF THE RIVER

For the purpose of this paper the river has been divided into five zones and, though these were based on physical features, it was found that the zonation of the fauna followed the same pattern.

ZONE I: SOURCE (4,000 to 5,000 feet)

The mountain streams, which form the Great Berg River, have two main types of source:

1. *Cliff Waterfalls* (Plate XA). Numbers of streams start as seepages into the cliff regions near the top of the peaks of Table Mountain sandstone. These damp cliffs, or ravines, are usually covered with moss and water-loving vegetation, mainly *Scirpus digitatus* and *Pentaschistis capensis*, through which the water drips or runs in a series of small waterfalls. During rain, strong waterfalls are formed as there is a direct run-off from the mountainside.
2. '*Sponges*' (Plate XB). These swamp areas are to be found on flatter mountain tops and small plateau areas, which are very limited in the jagged ranges

where the Great Berg River begins. These sponges are completely overgrown with swamp vegetation. Drainage streams often run down cliff waterfalls, but some run straight into mountain torrents.

Water conditions: From the few records available, temperatures seem to be slightly lower than in the zone below; pH—between 4 and 5; dissolved solids—very low; turbidities—negligible.

ZONE II: MOUNTAIN TORRENT ZONE (1,000 to 4,000 feet) (Station 1) (Plate XI)

The bed in this zone slopes steeply and the stream, constituting the headwaters of the Great Berg proper, drops about 3,000 feet in six miles. The bed is unstable and stony and is broken up by large rocks which create numerous cascades and occasional small waterfalls, between which are small runs and stickles.

There are numerous small pools and backwaters floored with stones, and little or no sand settles anywhere. On more permanent rock surfaces, especially those of waterfalls, there are patches of aquatic moss and *Scirpus digitatus*.

During flood periods, stones and even small rocks are on the move, producing much 'molar' action. However, because of the distinct step formation of the bed, current speeds during normal flow periods are rather slow in the runs and stickles, especially in the summer.

The banks consist of boulders and stone beaches but there are occasional patches of the coarse reed, *Prionium serratum* or 'palmiet', here and there. These patches increase in extent as this zone grades into the next.

Water conditions: Temperature—8.9° C. (winter minimum) to 22.8° C. (summer maximum); pH—4.3 to 5.9; total dissolved solids—10 to 40 p.p.m.; turbidities—negligible.

ZONE III: FOOTHILL, STONY RUN ZONE (300 to 1,000 feet)

This zone has been divided into upper and lower sub-zones.

Sub-zone IIIA (Stations 3 and 5) (Plate XII, A and B)

This part of the river drops about 500 feet in four miles and the bed is, therefore, less steep and more stable than in the zone above. The river here is in the form of a fast-flowing trout stream and the bed consists of long stretches of runs and stickles floored with stones and pebbles, interspersed with large flats and pools floored with clean stones and white, quartzitic sand. Some of the runs, flats and shallower pools are floored with large patches of *Scirpus digitatus* growing on firm stony bottoms. A small amount of sand settles under stones in runs and stickles and small amounts of fine silt are present in the more sheltered backwaters.

Banks consist of stony beaches with some sand along some of the larger pools. However, these sand beaches are usually overgrown with *Prionium serratum* which also grows along the edges of runs and stickles and is often partially submerged, especially in winter.

Water conditions: Temperature—9.0° C. (winter minimum) to 29.0° C. (summer maximum); pH—4.7 to 6.8; total dissolved solids—19 to 78 p.p.m.; turbidities—0.0 to 6.0 p.p.m. SiO₂.

Sub-zone IIIB (Stations 9, 10, 11 and 12) (Plate XIII, A and B)

The drop in this zone is about 200 feet in 25 miles. The bed is still broken up into stony runs, stickles and large pools, some of which are over 6 feet deep, but the flats and pools are floored almost entirely with quartzitic sand and what stony bottoms there are tend to be silted over. A certain amount of sand also settles under stones in the current, the amount depending on the speed. *Scirpus digitatus* has disappeared.

In this zone the river begins to pass through farm lands and the run-off water carries muddy silt which tends to form a fine deposit on stones, sandy bottoms and the vegetation in backwaters. In the lower part of this zone (Station 12—Wellington) this silt is even found in rapid runs and stickles and is freed when stones are disturbed.

The banks may be of bare stone or sand but usually they are overgrown with palmiet growing right down into the water; in the lower parts of the zone, the sandy banks are partly covered with grass, mostly *Paspalum vaginatum*, which also grows right into the water (Plate XIII A). As in the lower part of IIIA, in sections where the bed is wider, the watercourse is greatly broken up and numerous islands are formed, often consisting almost entirely of large patches of palmiet growing to a height of 4 feet or more.

Water conditions: Temperature—9.0° C. (winter minimum) to 32.5° C. (summer maximum); pH—5.9 to 7.3; total dissolved solids—18 to 91 p.p.m., with a very abnormal figure of 220 p.p.m. at Station 12 in February 1953; turbidities—0.0 to 185 p.p.m. SiO₂.

In Zone III the round river stones and quartzitic sand are derived almost entirely from Table Mountain sandstones, but some of the tributaries in this region run off French Hoek Bed and Cape Granite formations. At Wellington, Station 12, patches of Malmesbury slates, dipping at high angles, have been exposed but, even here, the main runs and stickles are floored with rounded quartzitic stones.

In runs and stickles throughout this whole zone, as well as in Zone II, varying amounts of vegetable debris, mainly leaves and twigs, are found trapped among the stones, the amount increasing in the lower reaches of Zone IIIB.

ZONE IV: FOOTHILL, SOFT BOTTOM ZONE (Just above sea-level to 300 feet)

(Stations 13, 14, 16, 18 and 19) (Plates XIV A, B, XV A, B, and XVI A)

Between Wellington and Hermon, at about the 250 ft. contour, the stony bed sections disappear and both the runs and the pools have soft bottoms. Fast-flowing sections are floored with fairly clean sand, often rather coarse, and pools are floored with sand or sandy mud. In the vicinity of Gouda, where the country is flat, the river has a rather canal-like aspect and is over 12 feet deep in parts even during periods of normal flow (Plate XVI A); in the wet season, when levels rise considerably, this canal-like stretch extends right back to Hermon, Station 13. This long pool is floored

with mud, sometimes as much as 6 inches deep, which rests on a mixture of coarse quartzitic sand, quartzitic pebbles and chips of Malmesbury slates. The mud always contains a large amount of vegetable debris.

Over the greater part of the zone pools are small and shallow (1 to 5 feet) and the bed is floored with quartzitic sand. During the dry season the flow is reduced to a mere trickle, between pools, forming shallow runs of not more than a few inches deep on sandy bottoms; at these times large parts of the sandy bed are exposed. Pools are floored with sand mixed with varying amounts of mud which increases in the more sheltered parts. The mud, and even the sand in pools and backwaters, often contain large amounts of leaf and twig remains (Plate XIV A).

During the wet season most of the exposed sandy areas become submerged and during floods the soft bottoms are scoured out; the deeper holes formed at this time, mainly under banks and against other obstructions, become the pools which are seen in the drier parts of the year (Plates XIV B and XV B).

Near Piketberg (Station 18) a small patch of underlying Malmesbury slates has been exposed resulting in a short section of stony runs and stickles which forms a small repetition of those in the zones above, only here, instead of rounded stones, the floor of the river consists of jagged pieces of slate resting on smaller chips and quartzitic pebbles. The main slate formations, protrude here and there (Plate XV A).

The banks are fringed with a variety of plants some of which are partly submerged, such as palmiet, the Cape Willow, *Salix capensis*, *Cyperus* spp., and the grass, *Paspalum vaginatum*. All these, especially the palmiet and the willows, do much to prevent bank erosion. At Gouda the marginal vegetation is fairly continuous but elsewhere there are extensive sandy beaches visible in the dry season. In winter much of the sand is submerged and the patchy vegetation extends to the water's edge.

Water conditions: Temperature—10.0° C. (winter minimum) to 31.7° C. (summer maximum); pH—6.4 to 8.2; total dissolved solids—45 to 584 p.p.m.; turbidity—0.0 to 13,000 p.p.m. SiO₂.

As stated before, in this zone the river runs through hilly grainlands where the soil is derived from the Malmesbury Series. After heavy rains, the run-off contains large quantities of fine silt later diluted by much larger volumes of cleaner water from the mountains. The run-off from these lands is also high in dissolved solids, especially chlorides, and this contributes to a marked rise in the dissolved solids content of the river water; however, low rainfall over the area minimizes the effect. Very occasionally rain falls here when little or none falls in the mountains, and on such occasions turbidity and dissolved solids rise considerably.

ZONE V: FLOOD PLAIN ZONE (Maximum height only a few feet above mean sea-level) (Station 21) (Plate XVI B)

This zone begins in the vicinity of the farm Caledonia near Hopefield, and merges into the estuary about two miles below the farm Kersfontein. The 'flood plain' which is flooded every winter, is a very restricted strip alongside the river, hemmed in by coastal hills. In some parts the flood waters fill small pans or vleis which hold water for some time after the floods have receded.

The main river here is canal-like, without pools and runs, and the bed is never exposed. Even in the dry season, depths of 3 to over 6 feet are common. In general, depths increase as the river merges with the estuary and the lower parts are navigable to sea-going fishing smacks.

Small tidal movements have been reported in the neighbourhood of Kersefontein during the drier months.

The bottom is mainly coarse quartzitic sand and pebbles mixed with chips of Malmesbury slates. Above this, there may be 2 or 3 inches of mud in the more sheltered parts. The mud always contains large quantities of leaf and twig remains and other vegetable matter.

Apart from a few muddy beaches, the precipitous banks are clothed with tall growths of *Phragmites communis*. Thick patches of *Cyperus textilis* also occur, mainly where the banks slope more gradually.

Water conditions: Temperature—9.0° C. (winter minimum) to 25.5° C. (summer maximum); pH—6.4 to 7.5; total dissolved solids—68 to 381 p.p.m.; turbidity—35 to 966 p.p.m. SiO₂.

The estuary, the upper part of which is very similar in appearance to Zone V, would constitute Zone VI but was not studied.

I. FLOW D. PHYSICAL AND CHEMICAL CONDITIONS IN THE RIVER

Table I gives flow figures obtained from the Department of Irrigation and were taken at the weir at Wellington. They indicate the general flow conditions in the Great Berg River.

TABLE I. FLOW FIGURES FROM WELLINGTON (STATION 12)

Figures in parentheses were those from Station 3 and are for comparison.

Month	Daily Rate of Flow			Number of High Floods over 5,000 cusecs
	Monthly total acre-feet	Monthly maximum cusecs	Monthly minimum cusecs	
1951				
April	65,391*	17,615*	3	1
May	81,382	9,411	156	2
June	257,934*	17,615*	483	5
July	130,199*	17,615*	596	3
August	60,220	8,413	390	1
September	60,446	13,631	390	1
October	52,131	10,876	300	1
November	33,602	13,631	129	1
December	8,104	345	34 (39)	
1952				
January	898	34	5 (13.2)	
February	344	26	1 (4.25)	
March	2,134	596	0.5 (5.26)	
April	2,840	189	26 (12.6)	
May	27,295	4,433	63 (16.8)	
June	11,779	994	63	
July	42,598	11,832	102	1
August	153,231*	17,615*	540	3
September	114,909*	17,615*	483	2
October	37,747	13,208	129	1
November	11,953	483	63	
December	2,760	156	10	

Month	Monthly total acre-feet	Daily Rate of Flow		Number of High Floods over 5,000 cusecs
		Monthly maximum cusecs	Monthly minimum cusecs	
1953				
January	458	15	1.8	
February	64	2.6	1	
March	568	34	5	
April	86,010*	17,615*	15	2
May	195,941*	17,615*	113	3
June	51,777*			
July	118,926*			
August	174,076*			
September	25,720			

* No discharge figures could be measured over 17,615 cusecs as gauge was then submerged. Total figures for these months should be much higher.

Figures published by permission of the Hydrographic Surveyor, Pretoria.

As will be seen from the table, the highest flow can be expected during the period of April to November but the actual peak periods depend on the time of onset of the main winter rains. In 1951, June was the peak month, but the flow in July was also high. In 1952 the main winter rains only began on July 24, and the maximum occurred in August and September. In 1953 the rains started early (April 11) and the peak flow occurred in May; however, the main flood period was the months of July and August.

During the months of maximum flow the daily flow is very irregular and most of the water rushes down during short flood periods. Some idea of the duration of these periods will be obtained from the graph of daily flow for the months of June and July 1951 (fig. 3). It will be seen that periods of heavy rains did not last for more than two days and floods dispersed within a few hours of the cessation of rain.

During summer and early autumn there is very little flow in the river. February is the month of lowest flow, but it should be mentioned that the very low figures recorded for this month at Wellington (2.5 cusecs on 15 days in 1952 and 1 cusec on 24 days in 1953) were due partly to water being drawn off for agricultural and domestic use. The minimum figures for February and March recorded in the Franschoek Forest Reserve (shown in parentheses on Table 1) are not as low, and the river still had to receive further water from two main tributaries before reaching Wellington.

The effects of these flow variations on general conditions and the biology of the river are as follows:

Flood Periods. These are periods of great disturbance; in Zone II the bed is greatly disturbed and stones and rocks are carried about and rolled; in Zone III the effect is less but there is still much rolling about of stones, sandy bottoms of pools are scoured out and mud and silt are on the move, especially in Zone IIIB. Increases in depth are variable and in some parts the bed is wide enough to allow flood water to spread out. In Zone IV the soft bottoms are on the move and are practically uninhabitable for bottom animals; in Zone V the effect on the permanent river-bed is not very marked as the flood waters spread out over a small flood plain, but current speeds are increased.

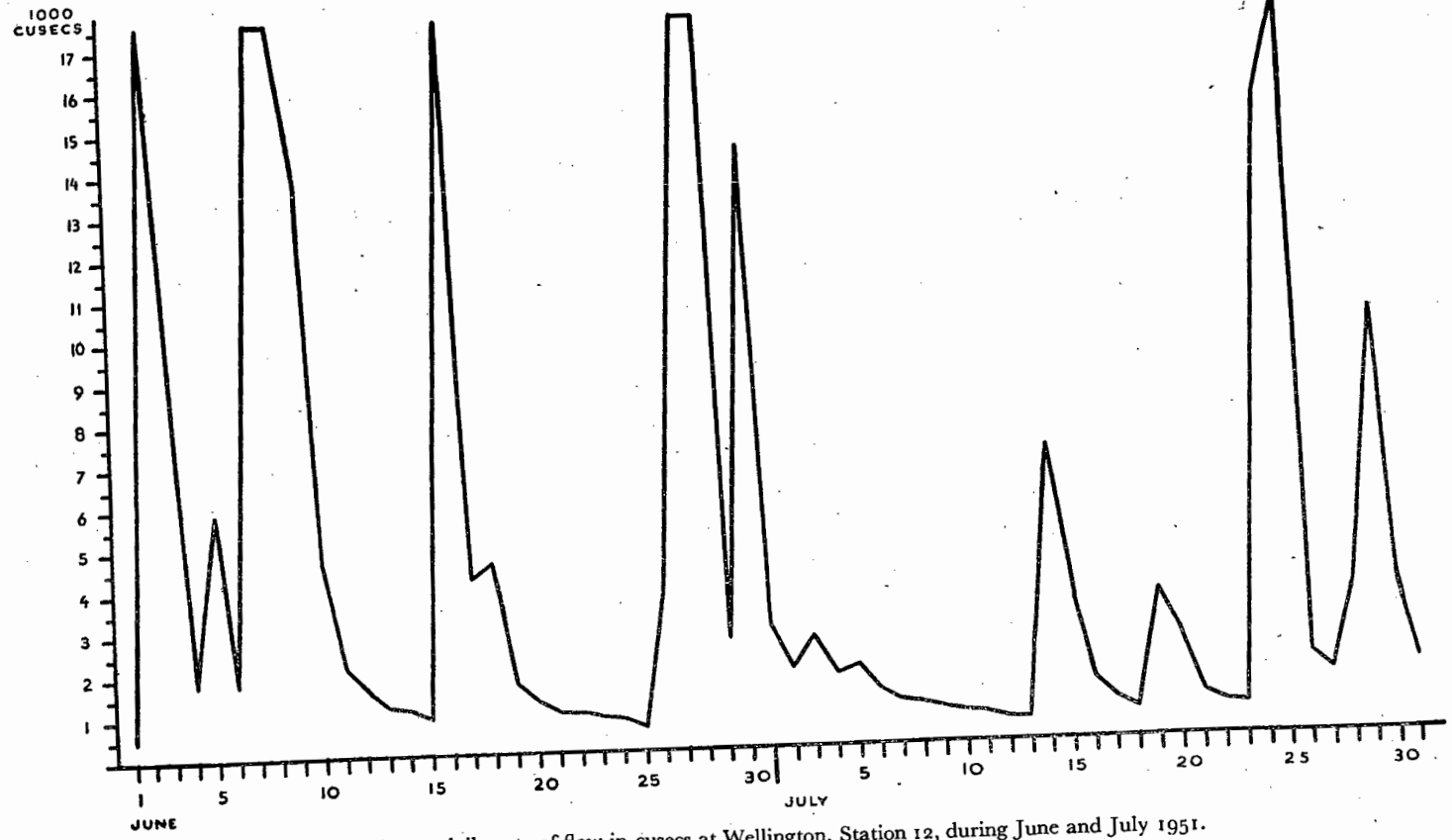


FIG. 3. Maximum daily rate of flow in cusecs at Wellington, Station 12, during June and July 1951. The short duration of flood periods is very apparent.

Periods of Minimum Flow. The actual area of bed colonized by aquatic animals is greatly reduced. The river-level associated with the minimum flow for any particular month is more or less the limit of colonization during that month, even when the water-level is higher, though very active bottom animals do move up with the water-level.

Current speeds (Table 2)

During periods of lower moderate flow the river is broken up into a system of pools with rapids between one level and the next. This is particularly evident in the stony reaches, but may even be seen in the sandy reaches of Zone IV. As a result there are local variations in current speed along the river. During heavy floods there is a marked change; as the water level rises inequalities of level disappear and current speeds become more uniform and are determined by the *average* slope of a particular section.

Information obtained about current speeds is summarized in Table 2.

TABLE 2. CURRENT SPEEDS: A SUMMARY

Zone	Station	Cascades		Runs and Stickles		Flats		Pools	
		Dry season cm./sec.	Wet season cm./sec.	Dry season cm./sec.	Wet season cm./sec.	Dry season cm./sec.	Wet season cm./sec.	Dry season cm./sec.	Wet season cm./sec.
II	1	90-112	150 and above :	25-88	52-98				
IIIA	3	90-135	too fast to be measured	22-52	115-135	4.5-10.5	Less than 30	Undetected	Not measured
IIIB	5	90		22-54	90-200	5 and less		Undetected 5 and less 12-18	12-30
IV				18-84	66-150				
V				21-55	60-92				

Wet season current speeds were measured between flood periods.

Zone V was considered as a 'pool'.

Zone I. No measurements were taken.

Zone II. Step formation of the bed in this zone is very marked and the stony stickles and runs between the small cascades and waterfalls are hardly sloped at all, so that, in the dry season and during periods of minimum winter flow, current speeds were rather low.

During flood periods there is a considerable increase in depth as the bed is narrow and restricted, and the whole stream becomes a raging torrent, runs, stickles and cascades being obscured by the rushing waters. Current speeds were not measured during these periods but they were fast enough to carry stones of 180 mm. or more, so they must have exceeded 300 cm./sec. (Nielsen).

It will be noted that speeds measured in interflood periods were less than those of the zones below; this was due to the step formation of the bed.

Zone IIIA. At Station 3, runs are long and sloping, though there is an occasional cascade. In the dry season true runs, as defined, tend to give way to a series of stickles. Again, fairly high current speeds must occur during floods, as, apart from some rolling of larger stones, small stones are carried about, of a size which would require speeds of about 200 cm./sec. (Nielsen).

At Station 5, in the lower part of this zone, dry season speeds were similar to those at Station 3, but as the stony runs here are even longer and during periods of normal wet season flow are deeper (60 to 70 cm.), wet weather flow was faster. While speeds of 90 to 135 cm./sec. were recorded from normal runs, speeds in the neighbourhood of 200 cm./sec. were not uncommon in the faster sections. During actual flood periods speeds must have been similar to those at Station 3, although the width of the bed allows a considerable spreading of flood water.

Zone IIIB. Stony runs and stickles in this zone varied greatly in their slope and the depth of water. Speeds varied from 18 to 84 cm./sec. in the dry season and from 66 to 90 cm./sec. in slower runs and 120 to 150 cm./sec. in the faster runs in the wet season. The run at Wellington (Station 12) is exceptionally steep. Even in the dry season speeds of 60 to 84 cm./sec. were normal and in the wet season speeds were between 90 and 135 cm./sec.

In runs, winter flood speeds must have been similar to those in the zone above, and in pools they were fast enough to stir up the sandy bottoms in the deepest places.

Zone IV. Current speeds were also very variable in this zone.

Dry Season: During this period the bed was broken up into a series of pools and shallow sandy runs; pool speeds were 5 cm./sec. or less and run speeds lay between 21 and 55 cm./sec. At Sanddrift, the lowest station on this zone where the bed though shallow (45 cm.) is more canal-like, speeds varied from 12 to 40 cm./sec. in mid-stream. In the stony runs and stickles at Piketberg (Station 18) current speeds varied from 27 to 48 cm./sec. However, it must be mentioned that most fauna samples were taken in places where the flow was between 42 and 48 cm./sec.

Wet Season: During interflood periods speeds of 60 to 75 cm./sec. were recorded on sandy bottoms and 65 to 92 cm./sec. in the stony runs at Piketberg. Floods would speed up the flow over the sandy bottoms but probably not much, if at all, over the stony bottoms which are then totally submerged and the step effect eliminated.

Zone V. Current speeds in the dry season varied from 18 cm./sec. in mid-stream to 12 cm./sec. near the banks. No figures are available for the wet season, but speeds must have been slower than in the zone above.

2. TEMPERATURES

Water temperatures were taken on practically every visit, and, in addition, daily temperatures were taken near Stations 3 (Franschhoek Forest Reserve), 12 (Welling-

ton), and 21 (Kersefontein) by observers at the Department of Irrigation's water-level gauges (Table 4). The valuable assistance of these observers has already been acknowledged.

Table 3 gives maximum and minimum values recorded for all the successive zones for the different seasons, based on all temperatures available. All these readings were taken in running water at a depth of about 3 or 4 inches. As will be seen, maximum temperatures were much lower in Zone II than in the zones below, especially in summer, but winter minimum temperatures were much the same throughout. The summer maximum was lower in Zone V than in the zone above; this was probably due to the fact that the water was much deeper.

TABLE 3. TEMPERATURES (BASED ON ALL RECORDS AVAILABLE)

Zone	Spring		Summer		Autumn		Winter	
	Max. °C.	Min. °C.	Max. °C.	Min. °C.	Max. °C.	Min. °C.	Max. °C.	Min. °C.
Zone II (Station 1)	15.0	10.0	22.8	17.5	21.8	10.0	12.5	8.9
Zone IIIA.	20.5	10.0	29.0	17.0	24.0	11.5	15.5	9.0
Zone IIIB.	25.0	12.0	32.5	21.0	30.0	11.0	14.5	9.0
Zone IV	23.0	15.0	31.7	22.5	24.0	12.0	17.8	10.0
Zone V (Station 21)	23.0	9.0	25.5	19.0	24.0	14.0	17.0	9.0

Table 3. These were all surface temperatures but were taken in fast, running water except at Station 21 where the flow was usually slow. In Zones II and IV records were only available from the monthly visits but in the other zones daily records were also available. A maximum and minimum thermometer was not used but the maximum and minimum shown were the highest and lowest temperatures recorded during the season in the zone.

Table 4 gives similar information but shows, in addition, that the rise and fall of succeeding monthly maximum and minimum temperatures are fairly gradual and that the difference between maximum and minimum temperatures exceeded 10° C. only during March 1952 at Station 12.

Standard deviations were largest at Station 3, during November and January, and at Station 12 during August, October, November, January and March. At Station 21 they did not exceed 1.8 for any one month.

During the summer months, when flow was very low, considerable stratification was observed in deeper pools, especially in Zones III and IV. For instance, on January 28, 1952, at Piketberg (Station 18), surface water in a pool at 4 p.m. was at 31.5° C. whereas water at 6 feet was at 21.5° C., a difference of 10° C. On this occasion the surface water was at the same temperature as that in the shallow sandy-bottomed runs between the pools. (Air temperature in the neighbourhood was about 40° C.) In Zone III similar stratification was encountered in the summer, and there were also considerable differences between the temperatures of the main stream and the backwaters, especially in the afternoon when the water had had time to

TABLE 5. WATER ANALYSIS, ZONE II (STATION I)

		1950				1951				1952			
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
pH	Mean	5.1	5.4	5.6	5.4	4.8	5.3	4.7	5.0	4.9			
	S.D.	0.5	0.6	0.2	0.2	0.4	0.2	0.3	0.1				
	Range	4.7-5.6	4.7-5.9	5.4-5.8	5.2-5.6	4.3-5.2	5.1-5.8	4.3-5.0	4.9-5.2				
Conductivity, micromhos	Mean	12.8	14.0	15.0	10.8	10.7	12.4	18.3	14.8	9.5			
	S.D.	0.3		2.1	1.2	1.8	0.1	4.0	2.5				
	Range	12.5-13.0		13.5-17.8	9.5-12.0	8.5-12.0	12-12.5	15.8-22.0	13.0-18.0				
Turbidity		The values were very low, average for whole period: 0.6 p.p.m.; maximum value: 2.5 p.p.m. (Winter 1951).											
Colour A.P.H.A. units	Mean						9'	12'	35	55			
	Range						7-10	5-10	20-45				
Total Dissolved Solids p.p.m.	Mean	34	29	21	20	16.5	12.2	27.4	27.6	13.6			
	S.D.	1.5	12	15	2	3.5	0.6	3.5	6				
	Range	33-36	14-37	10-40	18-22	13.7-20.7	12.0-13.3	24.0-31.4	21.8-33.2				
Total Alkalinity (as p.p.m. CaCO ₃)		The values lie between 1.0 and 2.0 p.p.m.											
Total Hardness (as p.p.m. CaCO ₃)		The values lie between 1.0 and 2.0 p.p.m.											
Ammoniacal nitrogen p.p.m. N	Mean	0.016	0.018	0.008	0.013	0.007	0.004	0.016'	0.012	0.006			
Albuminoid nitrogen p.p.m. N	Mean					0.018	0.049'	0.039'	0.029	0.052			
Nitrite p.p.m. N		The values all lie below 0.005 p.p.m., generally 0.000 p.p.m. Maximum 0.011 (Spring 1952).											
Nitrate p.p.m. N	Mean	0.035	0.11	0.03	0.05	0.14	0.08'	0.06'	0.11*	0.11			
Chloride p.p.m. Cl	Mean	4.1	5.6	5.7	3.9	4.1	5.7'	8.5'	6.5'	4.0			
	Range	3.0-5.2	4.4-7.2	5.2-6.8	3.2-4.4	3.0-4.8	5.6 & 3.8	8.0 & 9.0	6.0 & 7.0				
Iron p.p.m. Fe	Mean					0.20	0.55'	0.39'	0.19'				
Phosphate p.p.m. PO ₄	Mean					0.003	0.06'	0.001'					
Dissolved oxygen % saturation						100%	100%						
5-day B.O.D. p.p.m.						1.32'	0.30'						
4-hour O ₂ absorption p.p.m.				3.12*	2.28*	2.5	0.90	1.80	3.00	2.33			

* One reading each only.

' Average of two readings.

Note. From the Spring of 1951 pH colorimeter readings were checked, from time to time, against a Beckman meter; from Winter 1952 only meter readings were used.

TABLE 6. WATER ANALYSIS, ZONE IIIA (STATIONS 3 AND 5)

		1950	1951				1952		
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
pH	Mean	5.8	6.0	5.8	6.1	5.5	6.0	5.4	5.3
	S.D.	0.4	0.3	0.1	0.5	0.4	0.3	0.5	0.3
Conductivity, micromhos	Mean	21	24*	21	17	15	19	22	19
	S.D.	3.5		6.5	5.0	3.0	7.5	5.0	3.5
	Range	15.0-25.0		14.2-32.0	11.5-23.0	10.0-20.0	13.0-30.0	14.0-29.0	13.0-23.0
Turbidity p.p.m. SiO ₂	Mean	2.4	0.4	1.2	2.7	1.4	1.3	0.9	2.8
	Range	0.0-7.0	0.0-1.5	0.0-2.0	1.0-4.2	0.0-4.0	0.5-2.0	0.3-1.5	0.8-6.0
Colour APHA units	Mean						18	12	22
	Range						9-25	5-15	15-25
Total Dissolved Solids p.p.m.	Mean	35.3	42.0	32.0	31.0	24.4	22.2	30.0	34.5
	S.D.	8.0	15.5	12.5	11.0	5.0	3.0	5.8	6.4
	Range	25-51	24.0-78.0	18.0-48.0	19.0-5.2	17.2-29.8	14.0-29.6	21.6-38.0	23.2-41.0
Total Alkalinity (as CaCO ₃) p.p.m.	Mean	3.2	2.9	2.7	2.6	1.8	2.2	3.2	1.6
	Range	2.0-4.0	2.0-5.6	1.6-5.2	1.6-3.6	1.0-3.0	1.6-2.8	1.8-5.0	1.0-2.0
Total Hardness (as CaCO ₃) p.p.m.	Mean	2.9	3.5	—	3.5	2.5	2.7	4.3	4.3
	Range	0.5-4.4	2.4-4.8	—	2.2-5.2	1.4-3.7	1.7-3.8	2.6-6.7	2.4-5.4
Ammonia Nitrogen p.p.m. N	Mean	0.009	0.010	0.001	0.007	0.006	0.005	0.017	0.006
Albuminoid nitrogen p.p.m. N	Mean		0.024*	0.018		0.023	0.045	0.045	0.042
	S.D.					0.010	0.010	0.016	0.023
Nitrite p.p.m. N	Absent or very low values. Maximum: 0.020 (September 1950); mean: 0.002.								
Nitrate p.p.m. N	Mean	0.03	0.10	0.04	0.05	0.10	0.06	0.08	0.05*
Chloride p.p.m. Cl	Mean	8.6	8.9	7.7	6.4	5.8	7.9	11.1	9.3
	Range	6.4-9.8	4.8-13.4	5.2-12.4	4.4-8.8	3.6-7.6	6.0-10.2	9.0-14.0	7.0-11.0
Iron p.p.m. Fe	Mean	0.24	0.10			0.30	0.53	0.42	0.26
	Range	0.00-0.40	0.00-0.21			0.13-0.42	0.18-0.72	0.18-0.74	0.10-0.38
Dissolved Oxygen % saturation					98	97	90	93	
5-day B.O.D.	Mean					1.05	0.38	0.33	0.50
	S.D.					0.17	0.09	0.29	0.10
4-hour O ₂ absorption p.p.m.	Mean			1.70*		1.60	1.00	1.80	1.95
	S.D.					0.25	0.28	0.45	0.12

* One reading only.

Note. From the Spring of 1951 pH colorimeter readings were checked, from time to time, against a Beckman meter; from Winter 1952 only meter readings were used.

Ranges are given when fluctuations are large and standard deviations when the numbers of readings warrant.

TABLE 7. WATER ANALYSIS, ZONE IIIB (STATIONS 9, 10, 11 AND 12)

		1951			1952			1953		
		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
pH	Mean	6.3 ^a	6.6	6.8	6.9	6.8	6.5	6.5	6.7	6.4
	S.D.		0.3	0.5	0.2	0.3	0.2	0.2	0.2	0.4
Conductivity, micromhos	Mean	33 ^a	39	29	59	50	34	31	93	69
	S.D.	7.5	10	5	34	30	7	7.5	63	36
	Range	22-48	28-50	19.5-40	23-120	23-130	22.5-43	19-46	35-225	36-135
Turbidity p.p.m. SiO ₂	Mean	5.0 ^a	37.0	4.4	3.0	3.0	4.0	8.8	7.2	14.8
	S.D.			2.3	1.7	2.7	2.9	6.2	4.1	7.8
	Range	2.2-6.5	5.0-185	2.5-10.0	1.0-4.5	0.5-9.5	1.5-10.3	2.0-27.3	1.5-13.8	5.0-26.0
Total Dissolved Solids p.p.m.	Mean	65 ^a	52	37	61	58	51	49	101	85
	S.D.		20	11	24	29	7.5	8	57	76
	Range	40-91	24-82	18-49	33.4-87.4	22.4-14.0	39.8-63.2	36.6-63.2	49.6-220.2	54.8-151.0
Total Alkalinity (as CaCO ₃) p.p.m.	Mean	5.8	5.5	4.7	8.7	11.0	8.5	4.9	16.0	15.0
	S.D.	1.2	2.8	1.5	6.5	7.7	5.0	1.9	13.9	16.8
	Range	4.0-6.8	2.0-12.4	2.2-6.8	3.6-16.2	3.0-46.0	5.0-17.0	2.0-9.0	3.0-29.0	5.0-40.0
Total Hardness (as CaCO ₃) p.p.m.	Mean	—	8.0	6.9	12.0	12.1	8.7	7.9	20.2	16.0
	S.D.	—	3.5	2.0	8.2	9.9	2.0	2.4	12.4	17.1
	Range	—	5.1-16.8	4.0-10.5	3.8-21.0	5.4-34.5	6.6-10.8	4.2-12.4	7.6-41.5	11.6-38.0
Ammonia Nitrogen p.p.m. N	Mean	0.020 ^a	0.044	0.030	0.058	0.068	0.067 ^b	0.037	0.032	0.050
Albuminoid Ammonia p.p.m. N	Mean	—	0.113 ^b	0.044	0.046	0.111	0.099 ^b	0.079	0.013	0.092
Nitrite p.p.m. N	Mean	0.002 ^a	0.003	0.002	0.003	0.004	0.005 ^b	0.010	0.007	0.011
Nitrate p.p.m. N	Mean	0.10 ^a	0.23	0.10	0.25	0.14	0.07 ^b	0.07	0.08	0.13
Chloride p.p.m. Cl	Mean	13.1	13.2	11.3	18.1	20.1	15.7	13.8	39.6	27.2
	S.D.	2.3	3.2	2.1	7.7	8.6	2.6	3.0		
	Range	10.4-15.2	8.4-18.8	7.2-14.6	10.0-26.0	13.2-40.0	11.0-18.0	9.0-18.6	16.0-92.0	17.0-48.0
Iron p.p.m. Fe	Mean		13.6 [*]	0.52	1.39 ^a	0.82	0.36 ^b	0.54	1.44	1.68
Dissolved Oxygen % saturation	Mean	94 ^f	91 ^g	94	95	91	89	87	90	85
	S.D.			6	7.5	5	6	4	11	9
5-day B.O.D. p.p.m.	Mean	2.15 ^f	2.80 ^g	2.05	0.75	1.25	0.60	0.75	1.55	0.90
	S.D.			1.00	0.57	0.90	0.15	0.28	0.67	0.82
4-hour O ₂ absorption p.p.m.	Mean	2.95 ^b	2.35	1.05	0.65	1.90	1.55	2.20	1.50	1.60
	S.D.		1.22	0.24	0.23	1.14	0.19	0.87	0.42	0.48

^a = One value per station.^b = No values for Station 9.^f = 2 readings only per station.^g = Figures from Station 11 only.^{*} Exceptional value from Station 11 only, August.

Note: Only one set of values was obtained from Station 9 in Spring 1952, and only Stations 10 and 12 were sampled during Summer and Autumn 1953. From the Spring of 1951 pH colorimeter readings were checked, from time to time, against a Beckman meter, from Winter 1952 only meter readings were used. Ranges are given where fluctuations were large and standard deviations when the numbers of values warrant.

that the water in the Wemmer was very similar to that of the upper Great Berg, except that there was never any appreciable colour (see section on colour); sampling was therefore discontinued here after the first year of the survey. The Dwars River was studied for effects of possible pollution from the village of Pniel, from local farms and from a canning factory. Though biological effects were seen, water analyses were similar to those of the main river.

2. A far more important factor than contributions from tributaries is that the river here is running through agricultural areas growing mainly vines and deciduous fruit. This results in an increase of turbidity and the appearance of variable amounts of silt, especially during flood periods. Run-off from farm lands also leads to increasing mineralization.
3. In the Paarl-Wellington region there is a certain amount of domestic and industrial pollution, but although this is mentioned here and can be seen in Table 13, it will be discussed in detail in Part 4 of this series.
4. There is a small amount of run-off from the Malmesbury System near Wellington. This leads to additional mineralization and is especially noticeable in the high maximum figures for the summer of 1953 (Table 7).

Zone IV (Tables 8, 9 and 10). This zone is very long and includes most of the river. It has been divided up into three sections for the purpose of tabulating the seasonal results so that changes along its length would not be obscured. This was, of course, not necessary in Tables 12 and 13.

TABLE 8. WATER ANALYSIS, ZONE IV, SECTION A (STATION 13)

		1951 Autumn <i>April only</i>	Winter	Spring	1952 Summer	Autumn	Winter <i>June only</i>
pH	Mean	6.9	7.0	6.9	6.8	6.9	6.9
Conductivity, micromhos	Mean	85	95	40	142	57	68
	Range		55-160	36-43	60-230	52-60	
Turbidity p.p.m. SiO ₂	Mean	22.5	20	9	3.5	13.5	55.3
	Range		5.5-35	6.0-15	1.2-5.5	10.0-18.5	
Total Dissolved Solids p.p.m.	Mean	114	108	49	170 ^b	67	85
	Range		75.0-137	44.8-57.4	124.0-216.6	65.8-69.0	
Total Alkalinity (as CaCO ₃) p.p.m.	Mean	8.8	11.5	6.7	26.2	11.4	9.0
	Range		8.0-18.0	5.8-9.8	22.4-30.0	10.0-14.0	
Total Hardness (as CaCO ₃) p.p.m.	Mean		23.9	9.5	48.5	4.8	20.0
	Range		9.7-38.0	8.5-10.5	37.5-59.5	13.0-16.0	
Ammonia Nitrogen p.p.m. N	Mean	0.022	0.031	0.033	0.015 ^b	0.044	0.082
Albuminoid Ammonia p.p.m. N.	Mean			0.061	0.063 ^b	0.090	0.080
Nitrite p.p.m. N.		Absent or very low values; maximum 0.011 p.p.m. (May and June 1952).					
Nitrate p.p.m. N	Mean	0.57	0.33	0.26	0.075 ^b	0.12	0.13
Chloride p.p.m. Cl.	Mean	20.5	36.0	15.1	78.6	22.6	28.0
	Range		21.4-60.6	14.6-15.8	57.2-100.0	21.0-24.0	

TABLE 8 (continued)

		1951 Autumn <i>April only</i>	Winter	Spring	1952 Summer	Autumn	Winter <i>June only</i>
Iron p.p.m. Fe	Mean			1.08	1.29 ^b	0.84	1.34
Dissolved Oxygen % saturation	Mean			90	94 ^b	88	87
5-day B.O.D. p.p.m.	Mean			1.09	1.51 ^b	1.13	0.80
4-hour O ₂ absorption p.p.m.	Mean			1.46	0.87 ^b	2.31	3.29

^b = mean of two values only.

Note. From Spring 1951, pH colorimeter readings were checked, from time to time, against a Beckman meter, from Winter 1952 only meter readings were used. Ranges are given where fluctuations were large.

TABLE 9. WATER ANALYSIS, ZONE IV, SECTION B (STATION 14)

		1951 Autumn <i>May only</i>	Winter	Spring	1952 Summer	Autumn	Winter <i>June only</i>
pH	Mean	6.6	7.0	6.9	7.2*	7.4	7.0
Conductivity, micromhos	Mean	42	108	51	127	166	98
	Range		45-140	34-68	70-185	70-280	
Turbidity p.p.m. SiO ₂	Mean	42	55*	20	6*	62	60
	Range		50 and 60	16-27	1.5 and 10	14-157	
Total Dissolved Solids p.p.m.	Mean	51	108	60	150*	155	131
	Range		71-154	47.4-74.6	124.8-176.4	82.6-232.4	
Total Alkalinity (as CaCO ₃) p.p.m.	Mean	6	9.7	7.7	22.0*	33.8	11.0
	Range		12.8-16.8	5.4-9.6	18.6-25.4	16.0-62.0	
Total Hardness (as CaCO ₃) p.p.m.	Mean	7.1	20.6	11.8	40.7*	42.0	26.5
	Range		14.2-27.0	7.5-16.4	33.8-47.5	17.5-76.5	
Ammonia Nitrogen, p.p.m. N	Mean	0.016	0.033	0.015	0.016*	0.036	0.196
Albuminoid Ammonia p.p.m. N	Mean			0.061	0.093*	0.155	0.336
Nitrite p.p.m. N		Absent or very low values. Maximum: 0.012 p.p.m. (May and June 1952).					
Nitrate p.p.m. N	Mean	0.32	0.27	0.17	0.03*	0.12	0.23
Chloride p.p.m. Cl.	Mean	15.2	35.6	19.5	65.6*	65.1	40.0
	Range		16.8-58.0	14.4-26.2	54.2-77.0	28.4-108.0	
Iron p.p.m. Fe	Mean			1.29	3.66*	2.58	
Dissolved Oxygen % saturation	Mean			85*	93*	87	81
5-day B.O.D. p.p.m.	Mean			1.28*	1.12*	1.52	1.30
4-hour O ₂ absorption p.p.m.	Mean	5.40	1.82	1.40	1.20*	2.95	5.82

*Mean of two values only.

Note: From Spring 1951, pH colorimeter readings were checked, from time to time, against a Beckman pH meter, from Winter 1952 only meter readings were used. Ranges are given when fluctuations were large.

TABLE 10. WATER ANALYSIS, ZONE IV, SECTION C (STATIONS 16, 18 AND 19)

		Autumn ^a	1951 Winter	Spring	Summer	1952 Autumn	Winter ^b	Spring ^c	1953 Summer ^c	Autumn ^c	
pH	Mean	6.7	7.3	7.1	7.4	7.8	6.8	7.1	7.4	7.4	
	S.D.	0.3	0.1	0.2	0.2	0.3	0.1				
Conductivity, micromhos	Mean	45	120	55	270	210	135	94	160	160	
	S.D.	10	38	18	220	60	4				
	Range	35-58	70-160	30-82	36-720	80-250	103-139	69-105	93-260	115-200	
Turbidity p.p.m. SiO ₂	Mean	54	54	17	2,000*	80	297	45	10	55	
	S.D.	18	18	4		32	77				
	Range	25-80	25-70	12-26	1.5-13,000*	7-120	30-360	12-119	5-14	37-74	
Total Dissolved Solids p.p.m.	Mean	79	113	65	300	237	189	112	117	183	
	S.D.	27	22	12	184	59	17				
	Range	56-118	90-143	50-88	123-584	89-280	131-208	83-124	101-134	132-236	
Total Alkalinity (as CaCO ₃) p.p.m.	Mean	5.8	10.8	7.6	35.1	43.8	12.2	12.5	19.6	33.5	
	S.D.	0.8	1.5	5.3	13.0	17.5	3.1				
	Range	4.8-7.2	8.6-12.6	5.0-10.2	17.6-50.4	15.0-64.0	8.0-15.0	11.4-14.0	16.0-22.0	14.0-53.0	
Total Hardness (as CaCO ₃) p.p.m.	Mean	5.5	21.9	13.2	90.4	56.4	33.1	23.4	33.5	47.1	
	S.D.		11.2	5.0	41.6	15.7	4.0				
	Range	5.1-6.1	10.7-35.4	6.8-20.0	36.0-145.0	22.5-72.8	28.0-37.0	19.5-27.2	28.0-39.0	30.8-63.5	
Ammonia Nitrogen p.p.m. N	Mean	0.028	0.012	0.014	0.077	0.043	0.169	0.037	0.020	0.030	
	S.D.	0.015	0.015	0.005	0.106	0.029	0.027				
Albuminoid Ammonia p.p.m. N	Mean			0.067	0.166	0.165	0.471	0.099	0.071	0.129	
	S.D.			0.021	0.165	0.072	0.112				
Nitrite p.p.m. N		Absent or very low.									
Nitrate p.p.m. N	Mean	0.28	0.32	0.10	0.10	0.05	0.17	0.08	0.07	0.14	
	S.D.	0.09	0.15	0.04	0.09	0.04	0.03				
Chlorides p.p.m. Cl	Mean	16.6	40.6	20.8	150.8*	84.8	57.0	56.7	56.9	63.5	
	S.D.	2.6	10.4	7.4	89.7	23.0	5.2				
	Range	14.4-19.0	26.4-58.0	13.4-32.8	54.6-264.0*	32.6-113.0	50.0-61.0	30.0-60.0	25.0-108.6	48.0-79.0	
Iron p.p.m. Fe	Mean		2.24	1.68	18.7*	2.51	8.1	1.1	0.07	1.95	
	S.D.					1.1	5.0				
Dissolved Oxygen % saturation	Mean	94	105	97	85	95	100	96			
	S.D.	9	10	9	1	3	2	3			
5-day B.O.D. p.p.m.	Mean	0.85	1.40	1.95	1.35	0.80	1.30	1.00			
	S.D.	0.55	0.35	0.50	0.20	0.50	0.50				
4-hour O ₂ absorption p.p.m.	Mean	5.70		1.65	8.75*	2.90	8.40	1.80	0.80	1.53	
	S.D.	0.20		0.65		1.30	0.90				
	Range	5.40-5.81		1.13-2.58	0.69-35.65*	1.14-4.11	1.40-9.37	1.09-3.23	0.61-0.93		

^a = Two values per station only.

^b = One reading for Stations 16 and 19 and two for Station 18.

^c = Readings at Station 18 only.

* High values due to heavy run-off from farm lands, see discussion, high turbidity figures determined by dilution.

Note. From Spring 1951 pH colorimeter readings were checked, from time to time, against a Beckman meter; from Winter 1952 only meter readings were used. Ranges are given when fluctuations were large, standard deviations when the numbers of values warranted.

Section A. The river at Hermon (Station 13) (Table 8). The water here was practically of the same quality as at Wellington, except that signs of pollution had practically disappeared. No sizeable tributaries enter between the two stations, but local run-off from Malmesbury Series grainlands increases the turbidity and dissolved solids content in autumn and winter.

Section B. The river at Gouda (Station 14) (Table 9). The water here was originally very much the same as that at Hermon, but in the dry season of 1952, water from Voëlvlei Irrigation Dam was let into the river just above the sampling point. This water, which had been collected during the previous rainy season, had lain in a basin in the Malmesbury System for some months and was somewhat different in composition from that of the main river. Analysis showed that it had a much higher dissolved solids content (mostly chlorides) and a pH of 8.4. Its effects on the water at Station 14 were obvious during the autumn of 1952 and again in June, during which no appreciable volume of water had come down from the mountains (see Table 9).

Section C. This long section receives a number of important tributaries:

1. The Klein Berg River (Station 15)

This tributary makes a large contribution during the wet season but little or none during the dry season. The water was generally similar to that of the Great Berg although the pH was usually slightly higher and it was more turbid (range 14 to 64 p.p.m. as SiO_2).

2. The 'Twenty-four Rivers' Stream

This makes a fairly large contribution during the wet season but a very small one during the dry. The water comes straight off the near-by Great Winterhoek range (Table Mountain sandstone) and is of high quality, similar to that in Zone IIIA. This water must cause a slight dilution of dissolved solids in the main river during the rainy season.

3. Kuils River (Station 17)

This stream receives feeder streams from the mountains and also from the Malmesbury Series hills and farm lands in the neighbourhood of Porter-ville and Piketberg. Because of the latter run-off, dissolved solids were very high, especially when there had been heavy rains over the lowland areas. When most of the water originated in the mountains as judged by the volume in the feeder streams, the dissolved solids content fell, but when a large proportion fell on the grainlands the values were high and turbidities rose as there is much erosion in the area.

The following figures give some idea of the quality of the water at Station 17. The higher values were obtained when there was a high proportion of run-off from the farm lands:

pH:	7.4 to 8.2 (September 1951).
Conductivity:	275 to 2,200 micromhos (July 1951).

Total dissolved solids:	313 to 2,612 p.p.m. (July 1951).
Chlorides:	119 to 1,366 p.p.m. (July 1951).
Calcium:	8.8 to 88 p.p.m.
Magnesium:	16 to 132 p.p.m.
Turbidity:	11.5 to 38 p.p.m.

This stream seldom flows during the summer and early autumn unless there is unseasonable rain.

Station 16 was sited below the confluence of the Klein Berg and Twenty-four Rivers stream but above the inflow of the Kuils. Stations 18 and 19 were below the confluence of the Kuils and other smaller streams running off the Malmesbury Series (see Table 12).

Table 12 shows that there was a rise in total dissolved solids as the river passed through the Malmesbury District. Farming practices and clayey soils also led to a rise in turbidity especially in the wet season. In February 1952, the unseasonable rains over the region and run-off from the lands led to a considerable rise in turbidity and an unusual rise in dissolved solids. This may be seen from the results for Stations 18 and 19.

Zone V (Table 11). The only records for this zone are from Station 21 (see map). This station lies below the confluence of the Sout River (Station 20), the one main tributary entering this zone. Although this stream has a large catchment area, low rainfall over the district results in a very small contribution to the main river and during the months of December to March it dries up altogether. Nevertheless, as its run-off is all from the highly mineralized Malmesbury System, it increases the dissolved solids in the main river during the wet season.

TABLE 11. WATER ANALYSIS, ZONE V (STATION 21)

		1951			1952		
		Autumn ^b	Winter	Spring	Summer	Autumn	Winter ^a <i>June only</i>
pH	Mean	6.6	7.0	7.0	7.2	7.4	7.05
Conductivity micromhos	{ Mean	64	230	97	273	250	390
	{ Range	42 & 85	200-280	42-170	160-380	182-330	
Turbidity p.p.m. SiO ₂	{ Mean	140	135 ^b	57	37 ^a	80	966
	{ Range	140-140	120 & 150	55-90		40-145	
Total Dissolved Solids p.p.m.	{ Mean	94	248	104	334 ^b	273	381
	{ Range	68-114	232-274	73-156	292 & 374	224-328	
Total Alkalinity (as CaCO ₃) p.p.m.	{ Mean	6.8	14.3	9.5	31.6 ^b	43.1	30.0
	{ Range	5.6-8.0	10.8-18.2	6.4-12.0	29.2-34.0	29.2-57.0	
Total Hardness (as CaCO ₃) p.p.m.	{ Mean	6.6 ^a	41.6 ^b	24.0	86.3 ^b	64.7	100.0
	{ Range		19.3-63.8	10.8-42.0	77.5-95.2	50.5-79.6	
Ammonia nitrogen p.p.m. N	Mean	0.061	0.031	0.017	0.036 ^b	0.025	0.298
Albuminoid ammonia p.p.m. N	Mean			0.095	0.083 ^b	0.182	1.101
Nitrite		Absent or very low values.					
Nitrate p.p.m. N	Mean	0.23	0.35	0.21	0.03 ^b	0.04	0.40

TABLE 13. ANALYTICAL DATA REFERRING TO ORGANIC POLLUTION: RANGE OF VALUES OVER SURVEY PERIOD

Station	Ammoniacal Nitrogen p.p.m. N	Albuminoid Nitrogen p.p.m. N	Nitrite p.p.m. N	Nitrate p.p.m. N	Phosphate p.p.m. PO ₄	Dissolved Oxygen % saturation	5-day B.O.D. p.p.m.	3-minute O.A. p.p.m.	4-hour O.A. p.p.m.	
II	1	0·000-0·040	0·010-0·064 12/51	0·000-0·010	0·00-0·19 10/51	0·00-0·1 12/51	100-100	0·00-2·05 10/51	0·30-1·00	0·60-3·60 10/51
IIIA	3	0·000-0·028	0·006-0·054	0·000-0·011	0·00-0·15	0·000-0·09 12/51	89-100	0·20-0·95	below 1·00	0·60-2·20 4/52
	4	0·000-0·036	0·036-0·124	0·000-0·050	0·00-0·78 6/51	0·000-0·07 12/51	93-100	0·40-3·50 4/51	below 1·00	0·80-2·35 3/52
	5	0·000-0·024	0·018-0·074	0·000-0·020	0·00-0·18	0·000-0·08 12/51	82-100	0·00-1·35 10/51	below 1·00	0·90-2·25 5/52
IIIB	9	0·000-0·052	0·024-0·084	0·000-0·009	0·00-0·35	0·000-0·02	80-100	0·30-1·00	0·15-0·60	0·30-2·13 9/52
	10	0·000-0·040	0·034-0·094	0·000-0·012	0·00-0·36	0·000-0·05	89-100	0·20-1·90	0·10-1·10 11/52	0·45-3·50 11/52
	11	0·007-0·236 3/52	0·044-0·280 8/51	0·000-0·017	0·00-0·63 8/51	0·000-0·05	82-99	0·00-5·70 8/51	0·05-0·75	0·70-3·10 6/52
	12	0·016-0·142 4/52	0·050-0·318 2/53	0·000-0·015	0·03-0·55	0·000-0·06	0-99 3/52	0·00-5·70 2/52	0·10-1·67 3/52	0·90-4·81 3/52
IV	13	0·006-0·072	0·060-0·130 3/52	0·000-0·011	0·07-0·57 4/51	0·000-0·02	83-99	0·30-1·45 12/51	0·24-1·49 3/52	0·86-3·56 3/52
	14	0·008-0·196 6/52	0·056-0·336 6/52	0·000-0·012	0·01-0·32 5/51	0·000-0·5 5/52	81-99	0·80-2·10 5/52	0·27-1·90 5/52	0·98-5·82 6/52
	16	0·006-0·186 6/52	0·040-0·597 6/52	0·000-0·012	0·01-0·65 6/51	0·005 (<i>one value only</i>)	83-98	0·55-1·60 5, 6/52	0·17-1·71 6/52	0·88-7·21 6/52
	18	0·000-0·192 6/52	0·052-1·050 2/52	0·000-0·026 2/52	0·02-0·47 6/51	0·000-0·4 2/52	85-100	0·15-2·50 5/52	0·15-13·64 2/52	0·61-35·65 2/52
	19	0·000-0·130 6/52	0·058-0·515 2/52	0·000-0·012	0·02-0·45 6/51	0·005-0·01	81-100	0·25-2·50 4/52	0·24-4·07 2/52	0·85-13·40 2/53
V	21	0·004-0·298 6/52	0·058-1·010 6/52	0·000-0·014	0·01-0·58 6/51	0·000-1·1 6/52	71-96 6/52	0·55-3·30 5/52	0·15-5·00 6/52	0·96-33·5 6/52

Note. Dates below extreme values refer to months in which samples were taken.

The high winter values at Kersfontein (Station 21) may have been due to the inflow of the Sout River as explained above. Apart from the high value of 390 micromhos in June 1952 there were two dry-season values of over 300 micromhos which might have been due to marine influence. However, these results were more likely due to the effect of saline water from the Sout River during local rains, as explained above (*General Remarks*).

pH. In Zone II the pH was always low and no regular seasonal variations were noticeable, but an increase in the brown colour of the water (see section on Colour), most noticeable after heavy rains, was accompanied by a fall in pH. This occurred in November 1950, when the low figure of pH 4.7 was recorded.

In Zone III there was a tendency for the pH to increase in summer and there was also a marked rise in both the lower and upper extremes of the range downstream (Table 12). Values in the Franschoek Stream were usually about 1 pH unit higher than in the main stream.

In Zones IV and V, the highest pH values were recorded in autumn, except at Station 13; it will be noted that values were generally higher in autumn 1952 than in autumn 1951. This again seems to have been due to the influence of Voëlvlei water. (See page 156.) In Zone IV, the water was definitely alkaline.

Colour. It has been commonly observed that streams running down the seaward slopes of the Western Cape coastal ranges are strongly peat-stained, while those running off the landward slopes are normally only lightly stained, if at all. Thus the headwater streams of the Great Berg River, though acid, are not normally deeply coloured, except during heavy rains and flooding. It is interesting to compare the colour of the seaward Palmiet River, near by, with that of the upper Great Berg, as they both have their sources in the same mountain range; figures for the upper reaches of the Palmiet, taken in July 1952, were 75 and 100 A.P.H.A. units (turbidity: 1.3 and 1.8 p.p.m. as SiO_2), while the figure for Station 1 for the same month was 45 A.P.H.A. units (turbidity: 2.5 p.p.m. as SiO_2). The dark colour persists in the Palmiet during the dry season when it disappears in the upper Great Berg.

As has been mentioned in the section on pH, the colour intensity increases during periods of flooding and is generally higher in the rainy season; there seems to be a tendency for an increase in colour to be accompanied by an increase in the value for the four-hour oxygen absorbed from KMnO_4 test. This was to be expected, as the brown colouring matter is oxidizable organic material. (The Palmiet, with a colour of 100 A.P.H.A. units, gave a four-hour O.A. value of 9.5 p.p.m. as compared with much lower figures for Station 1.)

In spite of this, this colouring matter does not increase the five-day Biochemical Oxygen Demand values as it appears not to be easily oxidizable by bacteria; however, the low pH might have reduced the rate of bacterial oxidation.

The brown colour decreased in Zone IIIA and was hardly apparent in Zone IIIB. No readings have been given for the latter zone as the slight colour present there during floods was masked by turbidity. Disappearance of this colloidal pigment as the water progresses down the river is due to flocculation, as flocculated pigment can

be seen in some backwaters. Silt in Zone IIIB, during flood periods, probably hastens this process.

Total Dissolved Solids. In Zone II the relationship between total dissolved solids and conductivity was not constant; this was probably due to the organic substances producing colour and acidity which would be either non-ionized or very weakly ionized. Organic solids could not be determined with the apparatus available (nickel vessels).

Standard deviations showed that fluctuations of total dissolved solids in this zone were most marked in the summer and autumn of 1951 and during the winter of 1952 when the rains started late in July.

In the lower zones of the river, however, the correlation between conductivity and total dissolved solids was good, and in Zone V the ratio of conductivity to total dissolved solids gave the value: 1.00 ± 0.20 .

Values at Stations 14 and 16 (Zone IV) increased markedly during autumn of 1952 when Voëlvlei water was running in. This effect was obscured lower down where unseasonal February rains brought down the Kuils and other streams which sent up concentrations in the main river (584 p.p.m. at Station 18). As shown by Table 10, 1953 was a more normal year and values for summer and autumn in this region were much lower and although the autumn figures were again higher than those for 1951 this was probably due once again to release of Voëlvlei water.

As shown by Table 12, apart from the value of 381 p.p.m. for June 1952 at Station 21 (Zone V) other values exceeding 300 p.p.m. were: 375 p.p.m. (February 1952) and 382 p.p.m. (March 1952).

Turbidity. Turbidities were negligible at all times in Zone II and rose very little in Zone IIIA in spite of the effect of the Franschhoek Stream (Table 12). The high value of 145.0 p.p.m. (as SiO_2) was recorded from this stream in September 1950 during a flood period. In Zone IIIB the river makes its way through a fruit-farming district where muddy run-off might be expected, but, when the river was running normally, values were below 10 p.p.m. SiO_2 even during the rainy season. During flood periods, however, values rose sharply, but as samples were seldom taken during these extreme flood periods, the autumn, winter and spring averages and their standard deviations given in Table 7 really only apply to inter-flood periods. The figure of 185 p.p.m. from Station 11 in August 1951 gives some idea of the turbidity during flood periods in the lower part of this zone.

In Zone IV the turbidity was usually very low during the dry months and reached its peak during the winter floods. Extremely muddy water came down the Kuils and local streams when rain fell in the Malmesbury and Piketberg region in February 1952. Table 12 shows the effect of this in the values recorded for Stations 18 and 19 for this month. Normal winter maxima for these two stations were 360 and 188 p.p.m. SiO_2 , respectively.

In Zone V the highest values occurred in autumn and winter (Table 1) or the beginning of the rainy season. The value for June 1952 (Table 12) was taken when the river was in mild flood with a high proportion of local water.

Total Alkalinities and Total Hardness. As will be seen from the tables, values for Zone II were extremely low and there was very little rise in Zone IIIA. This very poor buffering of the water helps to account for the low pH and for month-to-month pH fluctuations. There was a tendency for values to rise in the late summer and autumn but this was more evident in the zones below.

From Zone IIIB down there was a large rise in maximum values, but minimum values recorded during rainy periods when the river contained mostly water from the mountains only rose slightly. Maximum values were obtained when there was a large proportion of Malmesbury System water in the river (cf. February 1952, Stations 18 and 19, Table 12).

Chlorides. The chloride ion was found to be the main anion of the Great Berg River water, and chloride values followed those for total dissolved solids very closely. Waters coming off the mountains were low in chlorides but values were slightly higher in the dry season; the apparent exception to this, the winter of 1952 (Table 4), was almost certainly due to the fact that rains were very late that season.

Maximal values rose steadily throughout the lower zones, and the higher values in Zones IV and V resulted from unusually high proportions of Malmesbury Series waters which are rich in alkali chlorides (see values for Stations 16, 18 and 19, summer 1952, Table 10, and February 1952, Table 12).

Sulphates. Figures were very low and sometimes sulphates could not be detected in Zone II, or even in Zone III and below. Once again, it was only water from the Malmesbury Series that showed appreciable sulphates (see figures for Stations 18 and 19, February 1952, Table 12).

Silica. Values were very low and no pattern could be discerned.

Calcium and Magnesium. The mountain waters were extremely low in these two cations (cf. figures for alkalinities and hardness), but as usual there was a steady rise downstream. Values were always higher in the dry season, but while they were highest in summer and fell off in autumn in Zone IIIB, in Zone IV they were at a maximum in autumn when magnesium became dominant over calcium. In Zone V magnesium was always dominant over calcium. In the Kuils, where there was much run-off from Malmesbury Series formations, magnesium was also always dominant over calcium.

Iron. Values were low in Zone II but reached their maximum in the dry season. In the lower zones, high figures were linked with high silt loads as reflected by the turbidities (cf. Station 11 in August 1951, 16 in June 1952, 18 in February 1952, 19 in February 1952, 21 in June 1952, all on Table 12).

Manganese. No tests were done on Zone II water but in four samples taken at different times from the main stream in Zone IIIA no manganese was detected. In four samples taken in Zone IIIB a trace was found in one only, which was taken at Station 12 in January 1952.

In Zone IV tests were done in August 1951 and in January 1952; none was detected in the August samples, but those for January gave the following figures:

Station 13—0.18 p.p.m.; Station 14—0.08 p.p.m.; Station 16—0.06 p.p.m.; Station 18—0.06 p.p.m.; Station 19—0.16 p.p.m.

At Station 21 (Zone V) no trace was detected in September 1951, but a sample taken in January 1952 gave the value 0.06 p.p.m.

The following are usually associated with organic pollution:

Ammoniacal Nitrogen. Figures for Zones II and IIIA were extremely low during all seasons and there was no obvious seasonal variations in these or in the zones below. In Zone IIIB higher figures than normal were sometimes recorded when other signs of pollution were present, especially at Station 11 (Daljosaphat) (March 1952, Table 13). In spite of this visible pollution, however, ammoniacal nitrogen figures were always very low.

In the zones below, values were usually very low with no obvious seasonal variations though values fluctuated more in the rainy season than in the dry. The value of 0.298 p.p.m. at Station 21 in June 1952 (Table 13) was exceptional as values generally lay below 0.060 p.p.m., except for one other value (0.092 p.p.m. in April 1951).

Albuminoid Nitrogen. Values were practically always low throughout the whole river. The fact that the values in Zone II were higher than those for ammoniacal nitrogen, must be linked with the organic peaty material in the water. Lower down, values above normal were linked with organic pollution of various types; at Stations 11 and 12 with domestic and industrial pollution, and in Zones IV and V with exceptional quantities of silt from the surrounding farm lands such as occurred at Station 18 in February 1952 and at Station 21 in June 1952 (Table 13).

Nitrate. Values were very low and showed no obvious seasonal changes in Zones II and III. In Zone IV values were at their lowest in summer and rose to a maximum in late autumn and winter. It is interesting to note that the value for the sample for February 1952 at Station 18, which carried farm-land run-off, was normal (0.25 p.p.m.).

In Zone V no obvious seasonal variations were apparent and values were very low.

Nitrite. Values were very low on all occasions and frequently nitrites were not detectable (Table 13).

Phosphate. Determinations were not done regularly, so that nothing can be said about seasonal variations in any part of the river. Values were usually very low, throughout, and often no phosphate could be detected; the figure of 0.1 p.p.m. (December 1951) from Zone II was exceptional, all other figures for this zone being below 0.01 p.p.m.

The value for the February 1952 sample from Station 18 was higher than usual (but cf. nitrates), and so was that from Station 14 in May 1952 which was taken during a flood when the value for total dissolved solids was also high (Table 13).

The highest value recorded was 1.1 p.p.m. (June 1952) at Station 21 when the river was heavily contaminated with run-off from local farms. Other values exceeding

0.1 p.p.m. at this station were: 0.35 p.p.m. (September 1951) and 0.4 p.p.m. (May 1952).

Dissolved Oxygen. Figures were nearly always high along the whole river and 100 per cent saturation, or just below, was frequent.

In Zone IIIA the two lowest values of 89% and 82% were both recorded in April 1952, the rest of the values being above 90% saturation (Tables 13 and 6).

There was no seasonal variation in Zone IIIB but a sample collected at Station 12 (Wellington) in March 1952 gave no oxygen at all; at the same time figures higher than normal were recorded for albuminoid ammonia (0.302 p.p.m.), and for the four-hour oxygen absorbed from $KMnO_4$ test (4.81 p.p.m.). The river was very low indeed at the time, and the flow was practically negligible at the spot where the sample was taken. The condition was probably very local, though fish in the vicinity were showing signs of distress.

In Zone IV no abnormally low value was recorded, but a value of 71% saturation at Station 21 (Zone V) was a further indication of the abnormal state of the river there in June 1952. (See under Turbidity, Iron, etc.)

5-day Biochemical Oxygen Demand. Only three samples for B.O.D. determination were collected in Zone II since this region suffers no organic pollution.

In Zones IIIA and IIIB there were no seasonal fluctuations, but Table 6 indicates that there was a greater range in autumn in Zone IIIA than in the other seasons. The comparatively high figure of 3.50 p.p.m. for the Franschoek Stream (Station 4) for April 1951 (Table 13) was probably due to a mild organic pollution, as were the figures for August 1951, at Station 11 (5.7 p.p.m.) and for February 1952, at Station 12 (5.7 p.p.m.).

In Zone IV there was no obvious seasonal variation (Tables 8, 9 and 10). Values between 2 and 2.5 p.p.m. were obtained at Station 18 on four occasions, at Station 19 twice and at Station 14 once. Unfortunately no determinations were done on the unusual water at Stations 18 and 19 in February 1952.

In Zone V values were often between 1.0 and 2.0 p.p.m., but that for the exceptionally muddy sample of June 1952 was only 1.60 p.p.m.

3-Minute Oxygen Absorption from $KMnO_4$. These values were to a certain extent related to the 4-hour O.A. values but were in no way proportional to them. (Compare maxima in Table 13.)

4-hour Oxygen Absorption from $KMnO_4$. Values were obviously related to the amount of organic matter present; however, there was no correlation between these values and those for B.O.D. as the organic matter was often derived from soils and was not of a type suitable for rapid oxidation by bacteria.

In Zone II values were often surprisingly high, and, apart from the maximum recorded in Table 13, other values exceeding 2.0 p.p.m. were: 3.10 p.p.m. (May 1951), 2.28 p.p.m. (June 1951), 2.15 p.p.m. (April 1952), 2.53 p.p.m. (May 1952), 2.73 p.p.m. (June 1952), 2.98 p.p.m. (July 1952), 3.20 p.p.m. (August 1952), 2.33 p.p.m. (September 1952). As mentioned in the section on colour, there seemed to be some relation between the 4-hour O.A. values and colour intensity, though

colourless organic acid substances in the water must complicate the issue. In general, the 4-hour O.A. values were higher in the wet season.

Figures were lower in Zone IIIA than those from the zone above, due, probably, to the reduction of the amounts of peaty substances in the water. Only four determinations were done on the Franschhoek Stream. Table 6 shows that the greatest fluctuations occurred in autumn.

In Zone IIIB no seasonal variations were apparent; values over 3.00 p.p.m. were obtained once from Station 10, once from Station 11 and five times from Station 12. These were no doubt due to organic pollution.

In Zones IV and V high values coincided with high turbidities and were usually encountered during floods. (Compare the maximum values recorded from Stations 18 and 19, in February 1952, with the turbidity values, Tables 12 and 13.) Other values above 3.00 p.p.m. were: Station 13—3.29 p.p.m. (June 1952); Station 14—5.40 p.p.m. (May 1951) and 4.93 p.p.m. (May 1952); Station 16—5.40 p.p.m. (May 1951), 3.19 p.p.m. (March 1952) and 4.11 p.p.m. (May 1952); Station 18—5.81 p.p.m. (May 1951), 3.01 p.p.m. (March 1952), 3.98 p.p.m. (May 1952), 9.36 p.p.m. (June 1952) and 3.23 p.p.m. (November 1952).

At Station 21 values lay between 3.00 and 6.00 p.p.m. on four occasions during the 15 months this station was sampled. The high value for June 1952 (33.5 p.p.m.) was exceptional and is associated with a high turbidity (Table 12). As mentioned in the relevant section above, this was not associated with a high B.O.D. value.

Main Features of the Changes in Water Quality Down the River

1. The bulk of the water in the river runs off Table Mountain sandstone and other poorly mineralized formations, so it is low in dissolved solids and poorly buffered. Organic 'peaty' substances derived from the acid sandstone soils give rise to low pH values and, sometimes, a brown colour, as well as unexpectedly high 4-hour O.A. values. These latter practically disappear in Zone IIIA; the exact reasons for this are not known but flocculation appears to take place.
2. The water starts off with practically no suspended matter but run-off from farms begins to produce turbidity in Zone IIIA. The position worsens rapidly as the river runs through grainlands from Hermon downwards, especially as the soils of the Malmesbury System are somewhat clayey. The turbidity in the lower zones bears some relation to the proportion of run-off from the farm lands.
3. There is the usual increase in dissolved mineral load as the water flows down the river; this is not great until the river runs through the Malmesbury System plain, run-off from which is highly mineralized, mainly with alkali chlorides. The increase in alkali chlorides in the main river bears a relation to the proportion of this run-off. As the rainfall in this area is low the rise is not as great as might be expected.

A good example of the correlation between rise in turbidity and rise in dissolved solids content with the proportion of run-off from Malmesbury Series farm lands can be seen in Table 12. At Station 18 maximum figures for both were recorded in February 1952 when local rains resulted in an unusually high proportion of this run-off.

E. MAIN FLORISTIC FEATURES

This survey did not include a detailed study of the aquatic and bank vegetation, but those species which provided a substratum for aquatic animals were collected and their distribution noted.

Submerged vegetation is very limited in the Great Berg, for the river is subjected to powerful scouring during the wet season and very few plants can establish themselves permanently in the bed. Only the firmest attachment to a non-eroding substratum will prevent the plants from being washed away. Dense growths are only found in the upper stony regions.

For the rest, the river vegetation is limited to the banks, but, as much of this grows out of the waters or dips into it, these plants form a very important lodging for small animals.

The following is the distribution of important species in the different zones:

ZONE I

1. *Cliff Waterfalls*. A large portion of the seepage area of the cliffs was overgrown with the grass, *Pentstemonis capensis* Stapf., but in parts where the water was running strongly this was largely replaced by *Scirpus digitatus* Boeck. Mixed with the latter, or forming large separate patches, was the aquatic moss, *Wardia hygrometrica* Harvey. Thick masses of *S. digitatus* and *W. hygrometrica* were often found covering the sheerest rock faces in regions where water was running or dripping and must have had to withstand a considerable force of water during the rainy season. Among these, *Sphagnum truncatum* Horns. emend. Garside and another aquatic moss, *Fissidens fasciculatus* Horns., were common (Plate XA).
2. *Sponges*. These were covered with mountain-top swamp vegetation which was not identified (Plate XB).

ZONE II

1. *Bed*. Most of the stony, unstable bed is quite unsuitable for aquatic vegetation but occasional patches of *Scirpus digitatus* occurred on the more stable surfaces of large boulders and waterfalls. *Wardia hygrometrica* was also fairly common in similar localities, especially in the upper parts of the zone, and occasional pieces of *Fissidens fasciculatus* were mixed with it.

During the autumn there was a growth of *Spirogyra* sp. and *Ulothrix* sp. in the backwaters and among the submerged portions of the marginal vegetation. *Batrachospermum* was common in summer.

2. *Banks*. In the lower parts of this zone small patches of 'palmiet' (*Prionium serratum*) appeared. Although the plants were usually stunted, they formed an important substratum for aquatic animals as the lower parts of the stem and leaves were often submerged, particularly during the wet season.

ZONE IIIA

1. *Bed*. Large patches of *Scirpus digitatus* were common in the fastest parts of the stream. At Station 3 one whole run was floored entirely with this weed, which has the growth habit of *Fontinalis antipyretica*. Where pools were floored with large stones, very large plants were growing, often in 3 to 4 feet of water. During the dry season parts of the runs and stickles were

exposed and the long trailing leaves died. But the plants remained alive and the aerial inflorescences appeared. When the wet season returned the leaves grew again rapidly. *Batrachospermum* was common in running water in summer and autumn.

2. *Banks.* The banks of the runs, stickles and pools were almost entirely fringed with *P. serratum*. Many stems and lower leaves, mostly dead, were submerged (Plate XIII A).

ZONE IIIB

1. *Bed.* *S. digitatus* does not extend as far down as Station 9, but a few small patches of a smaller species of *Scirpus* were found at the edge of some of the flats. It was not found below Station 9 and only once at Station 5 in Zone III A.

Samples taken from sandy bottoms of pools at Wellington in January 1955 contained small quantities of the following algae: Blue Greens: *Lyngbya cryptovaginata*, *Ocillatoria* spp., and *Merismopedia* sp.; Conjugales—*Oedogonium* sp., *Spirogyra* sp., *Desmidiium* sp., and *Holothea* sp.; Chlorococcales—*Scenedesmus* sp. *Batrachospermum* was found at Station 9 in summer.

2. *Banks.* *P. serratum* becomes more luxuriant along the pools and runs, but as usual most of it is left high and dry in summer and autumn. Lower down, between Paarl and Wellington, some of the sandy banks were carpeted with the grass *Paspalum vaginatum* Sw. and the lower edge of this extends into the water even during the driest periods (Plate XIII A). Here and there willow (*Salix capensis* and *Salix babylonica*) trail in the water.

ZONE IV

1. *Bed.* The sandy and muddy beds were quite bare during the wet season except for some *Nitella mucronata* which was found growing on sheltered muddy bottoms at Station 13 (Hermon) in spring. During the dry season patches of *Spirogyra* sp. appeared regularly in the shallow backwaters and slower parts of the current at Station 13, but this seldom occurred at other stations.
2. *Banks.* There were large patches of *P. serratum* throughout the zone interspersed extensively with *Salix capensis*; lower sandy banks here and there were clothed with *Paspalum vaginatum*. *Polygonum salicifolium* Brouss. and *P. acuminatum* Meisn. var. *capense* were common in protected parts among the palmiet and willows.

All the above species were partly submerged at all seasons. During winter floods numerous other bank plants were also submerged and provided temporary harbourage for stream animals for short periods (Plate XIV B); these included species of *Scirpus*, *Cyperus*, *Juncus* and *Cynodon* as well as *Asclepias* sp. at Station 19.

In the late summer and autumn most of the submerged vegetation was covered with a thin layer of mud matted with algae.

ZONE V

1. *Bed.* This was always entirely bare of vegetation.
2. *Banks.* Although the marginal vegetation in the upper part resembled that of Zone IV the *P. serratum* soon gave way to the reed *Phragmites communis* which formed a solid wall along the steeper banks. On the more gentle slopes there were large patches of *Cyperus textilis* growing right into the water (Plate XVIB). Both these were interspersed with occasional plants or patches of *Cliffortia strobilifera* and *Polygonum salicifolium* dipping into the water. However, *Phragmites communis* is undoubtedly the dominant type of vegetation and extends well down into the estuary below Zone V.

As seen in the zone above, a film of mud and algae appeared on the marginal vegetation in summer and autumn. However, in Zone V this mud film was thicker and contained fewer algal cells.

F. THE FAUNA

I. GENERAL REMARKS

As stated earlier, all the nets were made of grit gauze with 23 meshes to the inch (9 meshes to the centimetre). Thus each mesh was about 1 millimetre across so that most animals smaller than this would have passed through and would not have been included in the survey. These would include smaller Naididae, Cladocera, Copepoda, Ostracoda and Hydrachnellae, as well as early instars of some of the insect groups. However, when samples were taken from among vegetation, especially when there was some fouling resulting from organic pollution, there was considerable blocking of the meshes and smaller animals were captured.

In this paper the animal associations or 'faunas' of the various niches and zones have been dealt with on a seasonal basis. All stations were sampled monthly, except where otherwise stated, and these monthly results have been grouped as follows: those for September, October and November as 'Spring'; those for December, January and February as 'Summer'; those for March, April and May as 'Autumn'; and those for June, July and August as 'Winter'.

Various authors have proposed methods of selecting ecologically important species and have also proposed useful categories for them. Certain authors have used the species composition to define the limits of communities, especially when the physical differences between environments have not been easy to assess. Tansley (1923), when considering work of this nature, proposed such categories as 'exclusive species', those confined to one community, 'characteristic species', those commoner within the community than without it, and 'constant species', those present in every or nearly every example whether met with outside or not. Macfadyen (1954) uses 'differential species' to indicate ecological boundaries and defines them as 'species which are constant in all examples of a particular association of species . . . and are

mainly confined to that association'. He defines constancy rigidly as 'being present in 80% or more of samples in a sampling locality'.

In this survey it was not necessary to use the fauna to define ecological boundaries as the biotopes could be defined already in physical terms. The problem was to select species from the biotopes which really belonged there and to eliminate casual migrants from the discussion. These species had to be selected as being typical on the basis of their presence in a biotope over a long period of time and not on their presence in samples from numerous examples of the biotopes taken more or less simultaneously. Berg (1948), working on the results from a long period survey, selects 'characteristic species' or 'character animals' and defines such as 'a species which is fairly numerous, numerous or very numerous and which (a) in the main does not occur in other biotopes, or (b) is a denizen of at most a couple of biotopes (being in that case entered under both), or (c) which may live in several biotopes but quite plainly prefers the biotopes in question'.

However, as biotopes were not compared with one another initially in this survey, some other criteria had to be used. The term 'significant species' is used in this paper for species selected as follows:

1. In any individual sample from a biotope a species was selected if it constituted 5% or more of the total count. It was realized that, because of seasonal changes and individual life cycles, a species which normally thrived in a biotope might be absent for certain months of the year. Therefore the records for each season were considered separately and a species was selected as significant for the season if it occurred as 5% or more of the fauna in one or more of the three, monthly, samples.
2. There were a number of species which occurred in small numbers, but persistently, in the various biotopes. These, by virtue of their regular occurrence, were very characteristic of the fauna and could not be omitted from the list of significant animals. They included the large larvae of dragonflies and Megaloptera as well as smaller types such as Hydraenid beetles. These would be similar to Tansley's 'constant species'. A species, therefore, was also considered seasonally significant if it occurred in not less than two of the three monthly samplings from a biotope, no matter how few there were. In practice very few selected thus occurred for only two months.

The figures appearing on the tables below represent the number of significant species, as defined above, belonging to each family or group for the biotope and season indicated. If the family or group could not be sorted adequately the number of species distinguishable is followed by a plus sign indicating that more might have been present. If the family or group could not be sorted at all a 'p' has been inserted into the table merely indicating their presence.

2. THE DISTRIBUTION OF THE MAIN GROUPS OF AQUATIC ANIMALS

Table 14 is designed to give a general conspectus of the position of the main families and groups in the different zones. All species selected as significant have been

TABLE 14. NUMBER OF SIGNIFICANT SPECIES OF THE MAIN GROUPS

GROUPS	SPONGE	WATER-FALLS	STATIONS												ZONES								
			1	3	5	9	10	12	13	14	16	18	19	21	I	II	IIIA	IIIB	IV	V			
Hydra						p	p	p										p					
Planarians	p				p	p												p	p	p			
Nemertini						1	1	1	1	1	1	1	1	1							1	1	
Sphaeriidae									1	1											1		
Lymnaeidae						2	2	1	2	1	1										2	2	
Naididae		1	1	1	2	3	2	2	1	2	1	2	2	1				1	1	3	3	3	
Enchytraeidae				1															1				
Lumbricidae	1				3	3	1	3	3	2	1	1	1	1				1		3	3	3	
Tubificidae									1											1	1		
Polychaeta																						2	
Cladocera							1	5	1	2	1	1	2								5	2	
Ostracoda																						3	
Copepoda		1																1				p	
Gammaroidea	2*	1																2*					
Decapoda				1																1			
Nemouridae	p	2*	4*	4*	4*	3*	3*	2*										3*	4*	4*	3*		
Baetidae			6	7	6	7	7	9	5	4	4	7	4	4					6	8	10	8	4
Heptageniidae			1	1	1	1	1	1											1	1	1		
Leptophlebiidae			3	6	6	5	1	1											3	7	5		
Ephemerellidae		1	3	5	3	2	1											1	5	5	2		
Tricorythidae							1	1												1	1		
Caenidae				1	1	1	1	1	1			1	1	1						1	1	1	
Total Ephemeroptera		1	13	20	17	16	12	13	6	4	6	9	5	4				1	15	22	20	10	4
Zygoptera			1	1	1	1	1	1	2	1	1	1	1	1					2	1	1	2	1
Anisoptera			1	3	2	3	2	3	2	1	2	3	2						1	4	3	3	
Corixidae			1	1	1	1			3	2		2	3	4	3				1	1	3	4	3
Pleainae									1												1	1	
Notonectinae									1												1	1	
Ranatridae																						1	
Naucoridae													1	1								1	
Veliidae			2	2	2	2	2	2	2	2	2	2	2	2						2	2	2	2
Megaloptera		1	2	2		1													1	3	2	1	
Pyrilidae			1	1																1	1		
Sericostomatidae	2	1	1	2	2														3	3	2*		
Molannidae		1			1														1	2	1		
Leptoceridae			2	6	6	2	1	1	1										2*	8	2	1	
Hydropsychidae			1	1	1	1	1	1				1	2						2	1	1	3	
Philopotamidae			1	1	1														2	1			

(Continued)

TABLE 14 (continued)

GROUP	SPONGE	WATER-FALLS	STATIONS													ZONES						
			1	3	5	9	10	12	13	14	16	18	19	21	I	II	IIIA	IIIB	IV	V		
Polycentropidae				1	1	1												1	1			
Rhyacophilidae				1	1	1	1											1	1			
Hydroptilidae			3	2	1	2	1	1	1	1	1	1	1				3	3	2	2		
Total Caddis	2	2	8	13	14	7	4	3	2	1	2	3	1			4	14	18	7	6		
Dytiscidae								1			1								1	1		
Hydrophilidae											1								1	3	1	
Hydracnidae	1	2	4	2	1		1	3			1	1	2			3*	7*	2	3	4		
Helodidae	1	1	2	3	3	1										1*	2*	3	1			
Dryopidae	1	2	1	2	2											3	4	2				
Helmidae		1	3	3	4	3	3	1								1	5	4	3			
Gyrinid larvae	p					p		p	p	p						p			p			
Tipulidae			1	1	1								1					2*	1		1	
Dixidae			1	1	1		1											1	1	1		
Culididae		1						1										1	1	1		
Psychodidae		p																p				
Chironomidae	p	p	p	p	p	p	p	p	p	p	p	p	p	p		p	p	p	p	p	p	p
Ceratopogonidae		1						1					2	1		1			1	2		
Simuliidae	1	1	2	4	7	7	8	6	2		1	2	2			2	2	7	8	5		
Blepharoceridae			1	1	2	1												3	2	1		
Leptidae			p	p	p													p	p	p		
Empidae					1	1												p	p	p		
Tabanidae			p	p														p	p			
Hydrachnellae			p	p	p	p	p	p										p	p	p		
Tadpoles																						p

Table 14. Numbers in the columns indicate the numbers of species it was possible to distinguish. In the case of those figures followed by an asterisk, it is considered that a more exhaustive search for adult forms would have revealed further species. Where a *p* is inserted it was not possible to sort the groups to species

included in the figures given irrespective of season or the biotope from which they came. First, the species totals for the different stations are given and then those for the whole zone.

It is unfortunate that so important a family as the Chironomidae could not be sorted to species, but an appreciation of their distribution based on the imagines caught in the vicinity of the various stations will be given in Part 3, by K. M. F. Scott. The distribution of the images of Gyrinidae will also be dealt with in a subsequent paper.

Zone I: Source

1. *Cliff Waterfalls*. These biotopes were sampled on two occasions, once in spring and once in summer. The fauna consisted mainly of Gammaridae (mainly *Paramelita nigroculus*), Chironomidae (mostly Orthocladinae), *Simulium medusaeformis*, *Barbarochthon brunneum* (Sericostomatidae), and fewer numbers of Nemouridae, Hydraenidae, Helodidae (larvae), Dryopidae and Helmidae, Dixidae and Ceratopogonidae. The only Ephemeropterid found in these waterfalls was a species of *Lithogloea* (Ephemereleididae). When the flow was a mere trickle, odd larvae and pupae of Culicidae (*Neoculex* spp.) were also found.

The fauna of the damp moss and vegetation fringing these waterfalls included *Paramelita capensis* (Gammaridae), Psychodid larvae and Ceratopogonid larvae (including *Palpomyia* sp.).

2. *Sponges*. A stream in one of these was sampled in October 1951, in the 'Sneeugat', near the Great Winterhoek Peak at about 4,500 feet (Plate XB). Gammaridae (mainly *Paramelita nigroculus* var. *persetosus* (Barnard)) formed the bulk of the sample but Helodid larvae were also numerous.

The other animals present (Table 14) were fewer in number. Ephemeroptera were significantly absent, though both a small stream and a deep pool in the sponge were sampled. The Sericostomatid caddis were species of *Dyschimus* and *Rhoizema*.

Zone II: Mountain Torrent

Because of inaccessibility, only Station 1 on this zone was sampled regularly, but this was towards the lower part of the zone so samples were not considered to be as characteristic as they might have been. Excursions to the upper parts during spring and summer gave some idea of conditions there. A number of species, additional to those from Station 1, were found to be significant and have been included under this zone in Table 14. Again there was no *Scirpus digitatus* at Station 1 but patches were found during these excursions and significant animals from this habitat have been added to the zone total. This explains the discrepancy between the zone totals and the Station 1 totals.

At Station 1 regular samples were taken from stony stickles and runs, cascades, stony backwaters and marginal vegetation, and a few from the aquatic moss, *Wardia hygrometrica*.

The important features of the fauna were:

- (a) The presence of at least four species of Nouridae.
- (b) The presence of all Great Berg River families of Ephemeroptera, except the Tricorythidae and the Caenidae, the Ephemerellidae being prominent.
- (c) The presence of at least three species of Megaloptera (all Corydalidae).
- (d) The presence of a number of species of caddis, especially Molannidae-Beraeidae and Sericostomatidae. It is felt that the latter family is particularly characteristic of the upper parts of this zone; that more adequate collecting in these upper parts would have substantiated this is indicated by the number of species from this family which have been described by Barnard from mountain streams in the Western Cape Province.
- (e) The comparatively large number of species of clinging aquatic beetles (Hydraenidae, Dryopidae and Helmididae). There were more species in the upper than in the lower parts of the zone, and, if the criterion of significance had been ignored, the total would have been far higher. This is particularly true of Hydraenidae. Helodid larvae were always present.
- (f) Diptera. Only two species of *Simulium* were commonly present, though in heavily wooded side streams at least one other was found. Two species of Tipulid larvae were usually present but far more aquatic and semi-aquatic species have been recorded from the mountains by Wood. Blepharoceridae were usually present, usually *Elporia barnardi*, and this was joined in the upper parts by *E. capensis* and *E. spinulosa*; other species have been found by Barnard (1947).

Zone IIIA: Upper Foot-hill, Stony Run Zone

The following types of substratum were sampled regularly, stones in runs and stickles, stony backwaters, marginal vegetation and *Scirpus digitatus* in the current. Occasional samples were taken from *S. digitatus* in pools, and from sandy bottoms and marginal vegetation of pools.

The characteristics of the zone were:

- (a) The appearance of Naididae and Lumbricidae in the samples.
- (b) The very regular appearance of Nouridae.
- (c) The presence of all Berg River families of Ephemeroptera, except Tricorythidae, the Leptophlebididae and the Ephemerellidae being especially characteristic, and both had their maximum number of species in this zone.
- (d) The falling off of the Corydalidae (Megaloptera). Two species were fairly numerous at Station 3 but fell off at Station 5.
- (e) Pyralidae fell off at Station 5 but this was associated with the reduction of the amount of their food plant, *S. digitatus*.

- (f) The variety of caddis present, all Berg River families being represented. The number of species of Leptoceridae was at a maximum in this zone.
- (g) The presence of clinging beetles. The next section shows that the numbers of Helmidae were often high.
- (h) Diptera. The number of species of Simulium increased, Tipulid, Blepharocerid and Leptid larvae were still present, and Empids appeared.

Zone IIIB: Lower Foot-hill, Stony Run Zone

The following substrata were sampled regularly: stones in runs and stickles, marginal vegetation, sandy bottoms of pools. Stony backwaters and the sandy bottoms of deep pools at Station 9 were sampled occasionally.

Two main tendencies were observed in this zone:

- (a) This was found to be a zone of the falling away of most of the groups and species characteristic of the upper parts of the river. Families which disappeared entirely in this zone were the Nemouridae, the Leptophlebiidae, Ephemerellidae, Heptageniidae, Corydalidae, Pyralidae (Lepidoptera), the Trichopteran families, Sericostomatidae, Molannidae-Beraeidae, Philopotamidae, Polycentropidae and Rhyacophilidae, the Helodidae, Dryopidae, Helmidae, Blepharoceridae and Leptidae. There was also a reduction in the number of species of Leptoceridae, and the Tipulidae which are characteristic of the zone above, disappeared.
- (b) The fauna characteristic of the lower river began to appear. Groups and families which showed an increase in the number of significant species, or which appeared for the first time, were: the Nemertini, Lymnaeidae, Cladocera, Baetidae, Tricorythidae, Caenidae, Corixidae, Notonectidae, Dytiscidae, Hydrophilidae and Simuliidae. The latter family reached its maximum—8 species of *Simulium*.

Zone IV: Foot-hill, Soft Bottom Zone

Substrata sampled regularly were marginal vegetation, soft bottoms, both sandy, muddy and mixed, and stones in the current at Piketberg (Station 18).

In this zone the stony run and stickle fauna, characteristic of the upper zones, had disappeared and was not found even in stony runs and stickles at Station 18.

The vast majority of organisms were those adapted to soft bottoms and marginal vegetation. A certain amount of plankton appeared in the dry months when the river was low.

The main features of the fauna were:

- (a) The appearance of large numbers of Lumbricidae and some Sphaeridae wherever mud accumulated.
- (b) The Ephemeroptera were represented by the Baetidae, Tricorythidae and Caenidae only.
- (c) Corixidae were very numerous in the dry season and reached their maximum in number of species. There were a few Notonectinae and Pleainae.

- (d) There were a large number of sand-dwelling Dipterous larvae, mainly Chironominae but also Ceratopogonidae; Gomphinae were common but there was only one species.
- (e) There was a falling-off in the number of species of Simuliidae.

Zone V: Flood Plain

Situations sampled regularly were the marginal vegetation and the muddy bottoms.

The fauna of the marginal vegetation was much the same as in the zone above, but, as the next section will show, seasonal changes were more marked.

The main features were:

- (a) The appearance of animals of estuarine origin, mainly Polychaeta, but there was a sporadic occurrence of estuarine Amphipoda.
- (b) Ephemeroptera were represented by the Baetidae only.
- (c) There was a disappearance of sand and other soft bottom dwellers, mainly the Gomphinae (Anisoptera) and the Ceratopogonidae but also most of the Chironomidae.

3. THE COMPOSITION OF THE FAUNAS OF THE MAIN BIOTOPES

In this section the main biotopes are dealt with separately as follows: Firstly, a table is given to show the contribution made by the main groups and families to the species composition at the different stations; secondly, the significant species for each biotope are tabulated according to season. The average percentage composition for the season is given for those species which reached numerical importance somewhere along the river, and those which were 'constant' but not numerically important during the season are merely indicated under the relevant station. It will be seen, however, that, even though a species was numerically important in the samples from only one station, figures for all are given to complete the picture.

This section gives a fairly complete idea of the fauna of the river at the time of the survey and the composition of any future samples can be compared directly with that given in the tables; it also provides a basis for pollution studies.

Only those species which reach numerical prominence are discussed below; most of the rest are merely listed on the tables.

(a) *Fauna of Stones in the Current (Runs and Stickles)* (Tables 15 and 16)

Table 15 shows that in this biotope the following groups *decrease* down the river: Nemouridae decrease during the dry months and are always absent at Station 18; Leptophlebiidae reach their peak in Zone IIIA but disappear in Zone IIIB; the distribution of the Ephemerellidae is similar but they were found further downstream in the wet months than in the dry. The following also decrease downstream: Heptageniidae (one species only); Megaloptera (Corydalidae); all families of caddis except Hydropsychidae; all clinging beetles, Hydraenidae, Dryopidae, and Helmidae; Helodidae; Blepharoceridae (only significant during the wet season).

TABLE 15. SEASONAL DISTRIBUTION OF NUMBERS OF SPECIES OF MAIN GROUPS IN STONES IN CURRENT

GROUPS	¹				³				⁵				⁹				¹⁰				¹²				¹⁸					
	S.	S.	A.	W.	S.	S.	A.	W.	S.	S.	A.	W.	S.	S.	A.	W.	S.	S.	A.	W.	S.	S.	A.	W.	S.	S.	A.	W.		
Plumatella																														
Planarians								1								1														
Nemertini																														
Lymnaeidae																														
Naididae				1						1		1																		
Tubificidae																														
Enchytraeidae						1	1	1																						
Lumbricidae																														
Cladocera																														
Amphipoda																														
Decapoda																														
Nemouridae	2	2	3	2	2	2	3	3	2	2	3	3	2	1	1	3	2		1	3	2			2						
Heptageniidae			1	1		1	1	1		1	1	1																		
Baetidae	2	2	1	2	3	2	2	2	3	3	3	2	3	3	2	3	3	4	4	3	3	4	3	2	2	4	5	5	4	4
Leptophlebiidae	2	2	3	3	3	2	5	4	2	1	3	4	2	1	2															
Ephemereilidae	1	1	2	2	3	2	3	3	3	1	2	3	2		1	2	1													
Tricorythidae																														
Caenidae																														
Anisoptera			1			1	1			1	1																			
Megaloptera		2	1			1	2	1																						
Sericostomatidae		1						1	1		1	1																		
Molannidae																														
Leptoceridae						2	1	1	2	1	2	2	1																	
Hydropsychidae	1	1			1	1	1	1	1	1	1	1	1																	
Philopotamidae	1			1		1	1	1	1		1	1																		
Rhyacophilidae						1	1	1	1	1	1	1	1																	
Hydroptilidae							1																							
Hydraenidae		2	3	2		2		1		1																				
Helodidae	1	1	1	1	2	2	3	1	1	1	1	2	1																	
Dryopidae		1	1			1	1	1				1																		
Helmidae	2	3	2	2	2	3	3	2	2	3	3	2	2	2	3	1	1	3	2	1										
Gyrinidae																														
Tipulidae				1		1	1																							
Blepharoceridae	2			1		2		2	1			1																		
Chironomidae	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
Ceratopogonidae																														
Simuliidae	1	1	1	1	2	2	2	2	4	5	5	4	3	4	4	4	4	6	4	3	5	6	2	4	1	1	2	2		
Leptidae			p	p	p	p	p	p		p	p	p			p															
Empidae						p				p		p			p															
Tabanidae							p	p																						
Hydrachnellae	Usually present				at all stations but				passed through net.																					

Table 15. Numbers in the columns indicate the number of species which could be distinguished. A p indicates that the group was present but could not be sorted to species.

The following groups *increased* in species number downstream: Baetidae, Caenidae and Simuliidae, the first and last fall off again in Zone IV.

When looking at the tables it should be noted that, while there are runs from Station 1 to 12 there is a very large gap between the last patch of stony bed near Station 12 and the isolated patch of stony runs and stickles at Station 18. This accounts for the complete absence of many species. Details referred to below will be found in Table 16.

Nemertini. Though *Prostoma* sp. was often found, mainly in Zone IIIB, it only approached numerical importance at Station 12 in summer. Slight organic pollution resulted in deposits and algal growth on the stones which provided a more suitable lodging for the worms and their food animals at this station.

Polyzoa. There was a large amount of *Plumatella* at Station 12 in the summer, probably due to the organic pollution mentioned above.

Oligochaeta. The high percentage composition of *Nais* sp. can be linked with organic pollution; those at Station 9 may have been due to agricultural activity in the region. Note the high figure for Station 12 in the summer. Large Lumbricidae live under stones and were only important at Station 10 in autumn.

Nemouridae. These nymphs could not be sorted to species but only into two groups. The first included the nymphs of *Aphanicerca* spp., *Aphaniceropsis* spp. and *Desmonemoura pulchellum* which was probably rarer than the others. These were usually important at Stations 1 and 3 and it was only during the wet months that they occurred in numbers from Stations 5 to 12; Station 18 was well below their range. The second group comprised the nymphs of *Aphanicerella* spp., which were only significant in the autumn and winter, the highest percentage incidence being reported from Station 5.

Baetidae. *Baetis harrisoni* was a very important species and was practically limited to this habitat except during floods when the bed was disturbed. It was most prominent in winter and spring, from Stations 5 to 12, but in summer and autumn there was a falling-off in Zone IIIA and below. It was important also at Station 18 except in winter when the large quantities of moving sand might have discouraged it. *Baetis* sp. A. was characteristic of the lower parts of the river, especially Station 18 where a high percentage incidence was found in winter and spring. During these seasons it practically replaced *B. harrisoni*. *Acentrella capensis*, though found throughout Zones II and III, was not obtained in quantity at any time. The highest figures came from Station 1 in spring.

It is interesting to note that *Pseudocloeon vinosum*, which usually lives in vegetation, becomes more and more common among stones down river. This tendency is least apparent in summer, when numbers in the lower parts fall off generally. It may be due to one or more of the following factors:

- (1) Increasing amounts of large pieces of vegetable detritus caught between the stones which provide a suitable substratum, and
- (2) the stones becoming less 'clean' and thus providing a more suitable surface for them to cling to. This factor did not apply in the case of the winter

TABLE 16 (continued)

Order of stations in first row	II I				III A								IV 18			
	9				III B 10				12							
Order of stations in second row	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %
BAETIDAE																
<i>Baetis harrisoni</i> Brnrd.	3.5	25.3	23.5	12.8	15.3	12.4	4.2	18.2	52.4	15.1	7.9	25.4				
<i>Baetis</i> sp. A.	52.7	7.9	16.1	40.9	43.2	17.8	6.5	41.5	31.7	12.9	5.1	47.9	4.1	1.9	5.3	0.6
<i>Acentrella capensis</i> Brnrd.	—	—	—	—	0.1	—	0.2	1.2	—	—	3.1	3.3	23.7	0.3	3.2	36.2
<i>Pseudocloeon vinosum</i> Brnrd.	4.8	2.0	—	1.7	0.9	0.3	0.4	0.7	0.5	1.5	0.4	0.4	—	—	—	—
<i>Pseudocloeon maculosum</i> Crass.	1.4	0.4	0.4	2.7	3.5	0.9	—	0.2	1.1	0.2	0.1	2.1	—	—	—	—
<i>Centroptilum excisum</i> Brnrd.	—	0.1	—	—	0.6	0.7	1.1	—	0.9	0.9	—	0.5	—	—	—	—
	1.6	1.3	—	0.9	14.7	2.5	0.8	3.6	10.3	0.1	12.3	4.7	0.2	—	p	8.5
	—	—	—	—	—	—	—	—	—	p	p	p	—	p	p	—
	—	—	—	—	—	—	—	—	—	p	p	p	p	p	p	p
LEPTOPHLEBIIDAE																
<i>Aprionyx peterseni</i> (Lest.)	8.4	17.1	8.2	4.0	0.9	0.4	4.9	2.0	0.1	—	—	—	—	—	—	—
<i>Aprionyx intermedius</i> Brnrd.	0.1	—	p	4.7	—	—	p	0.1	—	—	—	—	—	—	—	—
<i>Adenophlebia peringueyella</i> Lest.	—	—	—	—	—	—	—	—	—	—	p	—	—	—	—	—
<i>Castanophlebia calida</i> Brnrd.	—	—	p	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Choroterpes nigrescens</i> Brnrd.	17.8	8.5	2.0	4.3	1.1	2.7	3.2	4.2	0.6	0.3	1.2	1.1	—	—	—	—
<i>Euthraulus elegans</i> Brnrd.	0.2	0.1	—	—	—	—	p	—	—	—	—	p	—	—	—	—
	—	—	—	—	—	—	p	p	p	—	p	p	—	—	—	—
	p	—	p	—	p	—	p	p	p	—	p	p	—	—	—	—
EPHEMERELLIDAE																
<i>Lithogloea harrisoni</i> Brnrd.	0.2	—	0.4	0.2	6.6	3.4	1.1	9.4	9.2	0.5	0.4	3.2	—	—	—	—
<i>Lithogloea pennicillata</i> Brnrd.	3.6	0.2	—	4.8	0.8	—	—	0.3	0.3	—	—	0.1	—	—	—	—
<i>Lithogloea</i> sp. A.	38.1	8.3	20.0	43.5	14.0	0.1	3.4	16.6	2.1	—	0.4	1.3	—	—	—	—
<i>Lithogloea</i> sp. B.	0.6	—	2.6	0.8	0.1	—	—	0.3	p	—	—	0.1	—	—	—	—
	—	—	—	—	—	p	p	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	p	—	—	—	p	—	—	—	—
	—	—	—	—	p	—	—	p	p	—	—	p	—	—	—	—

TRICORYTHIDAE																	
<i>Tricorythus discolor</i> Burm.	—	—	—	—	—	—	—	—	—	0.2	—	—	—	—	—	—	—
CAENIDAE																	
<i>Austrocaenis</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	0.1	0.1	—	0.3	—	0.3	3.2	1.1	0.9	0.9	0.8	2.4	3.0	7.6	8.1	0.5	—
ANISOPTERA																	
<i>Aeschna minuscula</i> Rambur	—	—	p	—	—	p	p	—	—	p	p	—	—	—	—	—	—
<i>Paragomphus cognatus</i> McLach.	—	p	p	p	—	p	p	—	—	p	—	p	—	p	—	—	—
MEGALOPTERA																	
<i>Chloroniella peringueyi</i> Esb.-Pet.	—	p	p	—	p	p	p	—	—	—	p	—	—	—	—	—	—
<i>Platychauliodes</i> sp.	—	p	—	—	—	p	—	—	—	—	—	—	—	—	—	—	—
SERICOSTOMATIDAE																	
<i>Petroplax</i> spp.	—	—	—	—	—	—	—	—	p	—	—	—	—	—	—	—	—
<i>Barbarochthon brunneum</i> Brnrd.	—	p	—	—	—	—	p	p	—	—	p	—	—	—	—	—	—
MOLANNIDAE																	
<i>Petrothrincus circularis</i> Brnrd.	—	—	—	—	—	—	—	—	—	p	—	—	—	—	—	—	—
LEPTOCERIDAE																	
<i>Athripsodes schoenobates</i> (Brnrd.)	—	—	—	—	—	—	p	p	—	—	—	—	—	—	—	—	—
<i>Athripsodes</i> sp., <i>scramasax</i> type	—	—	—	—	—	—	—	—	p	—	p	p	—	—	—	—	—
<i>Athripsodes</i> sp. C	—	—	—	p	p	p	—	—	—	—	—	—	—	—	—	—	—
<i>Oecetis modesta</i> (Brnrd.)	—	—	—	—	—	—	—	—	p	p	p	—	—	—	—	—	—
HYDROPSYCHIDAE																	
<i>Cheumatopsyche maculata</i> Moseley	—	1.8	0.3	0.1	2.1	7.2	3.3	0.5	1.2	8.5	7.5	1.8	—	—	—	—	—
<i>Cheumatopsyche zuluensis</i> (Brnrd.)	0.2	0.5	4.6	1.7	—	6.0	1.7	0.3	—	—	—	—	p	p	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	6.8	33.8	15.5	0.6	—

TABLE 16 (continued)

Order of stations in first row	II I				III A								IV 18			
	9				III B 10				12							
Order of stations in second row	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %
PHILOPOTAMIDAE																
<i>Chimarra ambulans</i> Brnrd.	—	<i>p</i>	—	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	—	—	<i>p</i>	—	—	—	—	—
RHYACOPHILIDAE																
<i>Myspoleo agilis</i> Brnrd.	—	—	—	—	0·3	1·6	1·4	0·8	7·2	3·2	4·8	8·0	—	—	—	—
HYDROPTILIDAE	0·8	1·5	—	0·4	0·1	1·7	—	—	—	—	—	—	—	—	—	—
<i>Hydroptila</i> sp. A	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—
Hydroptilid 'caraway seed'	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—
HYDRAENIDAE																
Sp. 8K	—	—	—	—	—	<i>p</i>	—	<i>p</i>	—	<i>p</i>	—	—	—	—	—	—
Sp. 6Y	—	<i>p</i>	<i>p</i>	<i>p</i>	—	—	<i>p</i>	—	—	—	<i>p</i>	—	—	—	—	—
Sp. 1Q	—	<i>p</i>	<i>p</i>	<i>p</i>	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—
Sp. 145D	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—
Sp. 520M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sp. 409A	—	—	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—
HELODIDAE																
Sp. A	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	—	—	<i>p</i>	—	—	—	—
Sp. B	<i>p</i>	—	—	—	<i>p</i>	<i>p</i>	<i>p</i>	—	—	<i>p</i>	<i>p</i>	—	—	—	—	—
Sp. C	—	—	—	—	—	—	<i>p</i>	—	—	—	—	<i>p</i>	—	—	—	—
DRYOPIDAE																
<i>Strina</i> sp. 7U	—	5·6	4·8	0·1	—	0·2	—	—	0·1	0·1	0·3	0·2	—	—	—	—
	—	—	0·4	—	—	—	—	—	—	—	—	—	—	—	—	—

HELMIDAE																	
Sp. 8J	0.4	1.6	1.6	0.4	17.6	9.3	14.1	5.5	2.8	9.0	14.0	6.7					
	0.3	0.5	6.9	4.3	—	1.1	8.8	2.1	—	—	—	0.2	—	—	—	—	—
Sp. 6AA	2.2	10.1	14.4	4.3	4.0	14.5	19.7	10.8	2.2	13.4	13.7	4.3	—	—	—	—	—
	0.3	1.3	6.9	0.1	0.4	1.4	0.2	—	p	0.2	0.1	—	—	—	—	—	—
Sp. 125E	—	—	—	—	—	p	—	—	—	p	—	—	—	—	—	—	—
	—	—	—	—	—	p	—	—	—	—	—	—	—	—	—	—	—
Sp. 81B	—	p	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
GYRINIDAE																	
<i>Aulonogyrus</i> larvae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	p	—	—	—	—	—	—	p	—	—	p	—	—	—	—	—
TIPULIDAE																	
<i>Limnophila nox</i> Alex.	—	—	—	p	p	p	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BLEPHAROCERIDAE																	
<i>Elporia barnardi</i> (Edw.)	4.0	—	—	8.6	0.1	—	—	0.2	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Elporia uniradius</i> Brnrd.	0.2	—	—	—	0.1	—	—	2.0	0.1	—	—	2.3	—	—	—	—	—
	—	—	—	0.4	—	—	—	0.6	—	—	—	—	—	—	—	—	—
CHIRONOMIDAE																	
Unsorted	0.6	0.2	4.9	0.3	1.6	12.1	11.7	1.9	3.0	11.9	4.8	3.5	—	—	—	—	—
	11.4	11.8	9.5	14.2	25.6	23.6	21.9	5.8	12.6	12.3	14.1	12.7	6.5	21.2	17.1	14.9	—
CERATOPOGONIDAE																	
<i>Atrichopogon victoriae</i> de M.	—	—	—	—	—	—	—	—	—	—	—	—	—	p	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SIMULIIDAE																	
Unsorted larvae and pupae	4.8	2.2	3.1	1.6	19.3	10.6	5.1	9.1	14.1	18.2	27.5	11.5	—	—	—	—	—
	13.6	67.4	19.4	16.8	7.7	27.2	27.3	37.8	25.5	6.2	56.7	11.8	4.6	0.5	3.5	28.6	—
LEPTIDAE																	
<i>Atherix</i> spp.	—	—	p	p	p	p	p	p	—	p	p	p	—	—	—	—	—
	—	—	p	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EMPIDAE																	
Clinocerinae	—	—	—	—	—	—	—	—	—	p	—	p	—	—	—	—	—
	—	—	p	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TABANIDAE																	
Unidentified	—	—	—	—	—	—	p	p	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 16. Figures in columns indicate the percentage incidence in the samples; p means: present in small numbers throughout the season. S. S. A. W.: Spring, Summer, Autumn, Winter.

samples from Station 18 where the fairly high incidence might have been due to the great disturbance set up by winter floods.

Pseudocloeon maculosum was found to be exclusive to this habitat in the lower parts of the river. High incidences were not encountered. *Centroptilum excisum*, a wanderer from backwaters, was sometimes found at Stations 12 and 18.

Heptageniidae. *Afronurus harrisoni* was most prominent between Stations 3 and 10, in summer and autumn.

Leptophlebiidae. This group was only numerically important at Stations 1 and 3. *Aprionyx peterseni* was characteristic of the runs and stickles at Station 1, in spring and summer, and was also fairly common at Station 3 in autumn and winter. *Castanophlebia calida* was also characteristically common at Station 1, especially in spring. The other species of Leptophlebiidae occurred in small numbers but formed a very characteristic part of the fauna of Zone IIIA especially in autumn and winter.

Ephemerelellidae. *Lithogloea harrisoni* was usually prominent from Stations 3 to 9, except in autumn when its main range was from Station 1 to 5. It moved right down to Station 12 during winter and spring. *Lithogloea pennicillata* was most characteristic of Station 1 where it was particularly prominent during winter and spring. It was still common at Station 3 during those seasons and odd specimens were found right down to Station 12. In summer it was most restricted. *Lithogloea* sp. A. was really a wanderer from *Scirpus digitatus*, and *Lithogloea* sp. B. which was rather rare was found to be fairly common in *Wardia hygrometrica* in the upper parts of Zone II.

Tricorythidae. Though *Tricorythus discolor* did occur sparingly in Zone IIIB it was very prominent at Station 18 in spring and was also important in summer and autumn. It was completely absent from winter samples.

Caenidae. *Austrocaenis* sp. was important at Station 18 except in winter when the floods would have washed it out.

Anisoptera. *Aeschna minuscula* was easily spotted because of its large size, but its incidence was low even in summer when it was most widespread. The highest summer incidence was 3.3% at Station 10. At Station 18 *Paragomphus cognatus* often wandered into stony runs and stickles from its usual habitat in sandy bottoms.

Trichoptera-Hydropsychidae. The highest incidence of *Cheumatopsyche maculata* was at Stations 3 and 5 in summer and Stations 3, 5 and 9 in autumn. *Cheumatopsyche zuluensis* was limited to Station 18 and was very prominent in summer and fairly common in autumn.

Trichoptera—Rhyacophilidae. *Myspoleo agilis* was mainly a species of Zone IIIA, especially Station 5 where its highest incidences were recorded in winter and spring.

Hydraenidae. These mainly occurred in Zones II and IIIA, but 520M and 409A were found lower down. It is apparent that far more of these would have been caught, especially the very small species 8K, if finer nets had been used in the survey. 8K is probably common in Zones II and III.

Helodidae. Larvae were often seen in the upper parts, but the incidence was always low. The highest incidence was for Species A from Station 1 in winter and

spring, when the seasonal averages were 2.3% and 3.0% respectively. Species B was mainly found in Zone IIIA, in summer and autumn. Species C occurred as a vagrant from vegetation.

Dryopidae. Species 7U (*Strina* sp.) was principally caught at Station 1 in summer and autumn.

Helmidae. This group of beetles was characteristic of Zone IIIA both as adults and larvae, though they were also common at Stations 9 and 10 in autumn and winter. Samples taken in the upper parts of Zone II showed that other species not mentioned on the tables were also common. Species 8J came into prominence at Station 3, but it was fairly evenly distributed throughout Zone IIIA except in spring when there were more in the upper parts. Its incidence in Zone IIIB in autumn and winter was higher than that of the next species. Species 6AA was mainly found in Zone IIIA but was also very common at Station 1 in summer and autumn.

Chironomidae. The percentage incidence of this group in Zone II was often very low, especially in the wet months; larvae were then very small and the majority must have passed through the meshes of the net as examination of stones under water showed numerous larvae of small Orthocladinae. In general the percentage incidence was higher in Zones IIIB and IV during all seasons than in the upper zones.

Simuliidae. The percentage incidence is based on the total larval and pupal counts; as the larvae could not be sorted to species they have been considered as a group. Distribution of species, determined from pupae, will be considered in Part 2, though the totals are given in Table 14 for all biotopes and in Table 15 for this biotope. With the exception of the high incidence in samples from Station 3 in spring, the highest figures came from the samples taken in summer and autumn from Zone IIIB.

Blepharoceridae. *Elporia barnardi* was only recorded in winter and spring, and the highest incidence was at Station 1. *E. uniradius* was also restricted to winter and spring, but the highest incidence was in Zone IIIA. Though the tables show very low incidences, larvae and pupae were often abundant on the submerged tops of large stones in the strongest parts of the current, usually on the downstream side. They were most commonly seen at Station 5.

(b) *Fauna in Cascades at Station 1 (Zone II)* (Table 17)

Table 17 gives the significant animals found in cascades at Station 1 (Zone II) (see Section C). The current was much stronger here than in the runs and stickles (Table 2), but the surfaces were more stable as the large rocks and boulders seldom moved during floods. The fauna should be compared with that of the stony runs and stickles at this station (Table 16); the main differences were certainly due to current speed and were particularly evident during winter. Winter current speeds reduced the percentage incidence of *Baetis harrisoni* but not of *Acentrella capensis*, *Lithogloea pennicillata* and *Castanophlebia calida*. *Aprionyx peterseni* was hardly present at any season and *Cheumatopsyche maculata* could only establish itself during summer and autumn when the river was low.

TABLE 17. SIGNIFICANT ANIMALS FROM CASCADES AT STATION 1

	Spring %	Summer %	Autumn %	Winter %
NEMOURIDAE				
<i>Aphanicera</i> sp. etc.	0.6	1.4	4.7	4.6
<i>Apanicercella</i> spp.				2.6
BAETIDAE				
<i>Baetis harrisoni</i> Brnrd.	8.3	4.9	18.9	0.2
<i>Acentrella capensis</i> Brnrd.	2.2	21.7	3.8	5.8
LEPTOPHLEBIIDAE				
<i>Castanophlebia calida</i> Brnrd.	3.2	0.3	5.2	5.6
EPHEMERELLIDAE				
<i>Lithogloea pennicillata</i> Brnrd.	31.5	3.5	14.3	49.5
HYDROPSYCHIDAE				
<i>Cheumatopsyche maculata</i> Moseley		<i>p</i>	<i>p</i>	
HELMIDAE				
Sp. 8J	<i>p</i>	<i>p</i>	<i>p</i>	
Sp. 6AA			7.3	1.4
BLEPHAROCERIDAE				
<i>Elporia barnardi</i> (Edw.)	27.8		0.3	21.0
CHIRONOMIDAE				
Unsorted	4.0	8.4	3.2	1.9
SIMULIIDAE				
Unsorted	20.3	52.3	35.7	3.1
EMPIDAE				
Clinocerinae		<i>p</i>		
HYDRACHNELLAE	Always present but passed through net.			

Table 17. Figures in columns show percentage incidence in samples; *p* means: present in small numbers throughout the season.

The incidence of Helmidae was much lower than in the normal stony bed, and Dryopidae and Helodidae could not establish themselves. *Elporia barnardi* showed its preference for this type of situation and incidence in September and October was over 40%. However, they disappeared in November and were absent throughout the summer and early autumn. Chironomidae were fairly common but, as mentioned above, many small free larvae were seen crawling on the rocks in the fastest parts of the current; most of these could have passed through the net. Simuliidae were naturally abundant here, but were greatly reduced during the winter. They were only of two species, *S. medusaeformis*, which was by far the more abundant, and *S. hessei*, which was very characteristic of this zone to which it was restricted.

The fauna was poorer in significant species than that of the runs and stickles.

(c) *Fauna of Stony Backwaters* (Tables 18 and 19)

This type of habitat was found only at Stations 1 to 10. Backwaters at Stations 1 to 5 were sampled every month but those at 9 and 10 only occasionally. Table 18 shows that the fauna had a very similar species pattern to that of the stones in the current with a rise in the number of Leptophlebiidae and caddis in Zone IIIA and a subsequent falling-off in Zone IIIB. The greater number of Nemouridae and Baetidae present at the upper stations (1 and 3) was probably due to the fact that

species that normally prefer running water were able to exist in backwaters there because these were cleaner, as well as cooler in summer, than those lower down.

Nemertini. *Prostoma* sp. was not usually found in this situation except in autumn samples from Stations 9 and 10, when conditions were somewhat muddy. *Prostoma* was commonly found on muddy bottoms in Zones IV and V.

TABLE 18. DISTRIBUTION OF SPECIES OF MAIN GROUPS IN STONY BACKWATERS

	II			IIIA						IIIB					
	S.	S.	A. W.	S.	S.	A. W.	S.	S.	A. W.	S.	S.	A. W.	S.	S.	A. W.
Nemertini															
Naididae							1	1		1			1		1
Lumbricidae							2	1							
Amphipoda				1											
Nemouridae	2	1	1	3			1		1	1					
Heptageniidae		1	1		1	1	1	1	1	1	1	1		1	
Baetidae	2	2	4	2	3	2	3	3	3	2	1	2			
Leptophlebiidae	1	3	3	2	5	5	4	5	4	4	2	4	2		
EphemereUidae	2	2	2	1	1	2	2	2	1	1	1	2			
Caenidae					1	1	1	1	1	1	1	1	1		1
Anisoptera		1				1			1	1	1		1	1	1
Corixidae					1	1			1	1				1	
Megaloptera		1													
Sericostomatidae					1				1						
Molannidae									1						
Leptoceridae	1	1	1	1	1	1	1	1	1	2	1	1			
Polycentropidae					1	1			1	1	1	1			
Hydroptilidae			1										1		
Dytiscidae					1										
Helodidae	1	1	1	1			3	1							
Helmidae	1	1	2	1	1	1	1	1	2	1	2	1	1		
Chironomidae	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
Leptidae		1	1				1	1							
Hydrachnellae		1	1		1										

There were no samples from Station 9 in summer and winter.

Table 18. Numbers in the columns indicate the number of species which could be distinguished. Chironomidae were usually present but it was not possible to sort larvae and pupae to species.

Nemouridae. Nymphs of *Aphanicerca* spp., *Aphanicercopsis* spp. and *Desmonomoura pulchellum*, which usually live in stony runs, strayed into the small backwaters at Station 1 during flood periods. *Aphanicercella* spp. seemed to be more at home in the backwaters and the highest figures were recorded from Stations 1 to 5 in autumn.

Heptageniidae. *Afronurus harrisoni* was mainly found in Zone IIIA but the incidence was low except at Station 5 in summer. During summer and autumn a few appeared at Station 1.

Baetidae. *Baetis harrisoni* was found in fair numbers in the backwaters of Zone IIIA during the winter and spring, but had probably strayed from the runs during the floods. The fairly high incidence of *Pseudocloeon vinosum*, which was mainly a vegetation dweller, at Station 1 in autumn, was probably due to growths of *Spirogyra* sp. which provided a suitable substratum. *Pseudocloeon* sp. A. was most characteristic of the backwaters in Zone II, both at Station 1 and higher up. The highest incidences

TABLE 19. SIGNIFICANT ANIMALS FROM SANDY BOTTOMS

	II				IIIA				IIIB				IIIC									
	S ¹ %	S ² %	A ³ %	W ⁴ %	S ¹ %	S ³ %	A ³ %	W ⁴ %	S ¹ %	S ⁵ %	A ⁵ %	W ⁵ %	S ¹ %	S ⁹ %	A ⁴ %	W ³ %	S ¹ %	S ¹⁰ %	A ⁴ %	W ⁵ %		
NEMERTINI																						
<i>Prostoma</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32.3	—	—	—	—	—	2.0	—
OLIGOCHAETA																						
* <i>Slavina appendiculata</i> (Udek)	—	—	—	—	—	—	—	—	1.4	1.3	—	—	10.0	—	—	—	—	—	—	—	1.0	—
* <i>Lumbriculus</i> sp.	—	—	—	—	—	—	—	—	<i>p</i>	<i>p</i>	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—
*Medium Lumbricids	—	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—
*Large Lumbricids	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—
AMPHIPODA																						
<i>Paramelita nigroculus</i> (Brnd.)	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NEMOURIDAE																						
<i>Aphanicerca</i> spp. etc.	1.3	1.1	—	5.8	—	—	—	0.3	0.4	—	—	0.9	—	—	—	—	—	—	—	—	—	2.7
<i>Aphanicerella</i> spp.	—	—	8.1	5.2	—	—	2.7	2.3	—	—	9.1	4.6	—	—	—	—	—	—	—	—	—	—
HEPTAGENIIDAE																						
<i>Afronurus harrisoni</i> Brnd.	—	0.3	0.8	—	0.5	0.2	1.3	1.0	0.3	8.4	3.7	0.5	—	—	—	—	0.2	—	—	—	—	—
BAETIDAE																						
<i>Baetis harrisoni</i> Brnd.	2.1	2.9	2.7	1.2	7.1	0.6	—	13.7	12.5	2.0	0.8	12.7	—	—	—	—	—	—	—	—	—	49.0
<i>Baetis bellus</i> Brnd.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23.0	—	—	—	—
<i>Pseudocloeon vinosum</i> Brnd.	—	—	5.8	—	—	—	1.3	—	0.3	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Pseudocloeon</i> sp. A	40.0	19.9	5.1	9.8	11.2	—	0.6	4.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
* <i>Centroptilum excisum</i> Brnd.	—	—	0.2	—	2.8	9.9	0.3	2.9	14.9	9.3	2.1	7.7	2.0	—	5.6	—	12.0	25.0	25.0	—	—	6.0
<i>Austrocloeon virgiliae</i> Brnd.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.0	—	—	—	—

LEPTOPHLEBIIDAE																			
<i>Aprionyx peterseni</i> (Lest.)	17.2	34.0	17.6	14.2	8.0	8.4	1.8	8.3	0.2	0.2	—	—	—	—	—	—	—	—	
<i>Aprionyx intermedius</i> Brnd.	—	—	4.1	—	1.1	0.8	22.8	1.0	0.6	0.8	10.5	1.8	—	—	—	—	—	—	
<i>Aprionyx tabularis</i> (Eaton)	—	—	—	—	—	4.1	1.8	—	12.9	29.6	6.6	0.4	0.3	—	—	0.1	—	—	
<i>Castanophlebia calida</i> Brnd.	—	0.5	1.7	11.8	0.8	0.5	0.5	1.0	—	—	—	0.2	—	—	—	—	—	—	
<i>Choroterpes nigrescens</i> Brnd.	—	1.4	—	—	6.5	4.3	—	2.7	0.4	2.1	0.3	0.2	0.1	—	—	—	—	—	
<i>Euthraulus elegans</i> Brnd.	—	—	—	—	<i>p</i>	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	
EPHEMERELLIDAE																			
<i>Lithogloea harrisoni</i> Brnd.	1.9	6.0	5.3	—	43.3	9.5	16.9	35.5	19.0	3.2	1.7	20.3	—	—	—	—	—	—	
<i>Lithogloea pennicillata</i> Brnd.	11.8	3.9	13.2	44.2	1.1	0.1	1.0	9.7	—	—	0.2	2.1	—	—	—	—	—	—	
CAENIDAE																			
* <i>Austrocaenis</i> sp.	—	—	—	—	1.2	0.9	1.0	0.5	5.5	6.7	3.0	1.8	20.0	—	6.1	50.0	—	17.0	6.0
ANISOPTERA																			
<i>Aeschna minuscula</i> McLach.	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
* <i>Paragomphus cognatus</i> (Rambur.)	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—
* <i>Trithemis</i> sp.	—	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	8.1	—	<i>p</i>	32.0	—
CORIXIDAE																			
* <i>Micronecta piccanin</i> Hutch.	—	—	—	—	0.2	—	0.4	—	—	0.6	12.6	—	—	—	—	1.5	—	—	—
MEGALOPTERA																			
<i>Chloroniella peringueyi</i> Esb.-Pet.	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SERICOSTOMATIDAE																			
<i>Petroplax</i> spp.	—	—	—	—	<i>p</i>	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—

TABLE 19 (continued)

	II				IIIA								IIIB								
	S ¹ %	S ² %	A %	W %	S ³ %	S ³ %	A %	W %	S ⁵ %	S ⁵ %	A %	W %	S ⁹ %	S ⁹ %	A ⁴ %	W ² %	S ¹⁰ %	S ¹⁰ %	A ⁴ %	W ⁵ %	
MOLANNIDAE																					
<i>Petrothrincus circularis</i> Brnd.	—	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	
LEPTOCERIDAE																					
<i>Athripsodes</i> sp. nr <i>scramasax</i> (Brnd.)	0·5	0·6	8·7	4·8	0·4	—	1·2	3·8	15·5	6·7	8·1	30·9	—	—	—	—	—	—	—	—	
<i>Athripsodes</i> sp. B	—	—	—	—	—	<i>p</i>	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	
POLYCENTROPIDAE																					
<i>Protodipseudopsis</i> sp.?	—	—	—	—	<i>p</i>	<i>p</i>	—	—	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	—	—	<i>p</i>	—	—	—	—	<i>p</i>	
HYDROPTILIDAE																					
<i>Hydroptila capensis</i> Brnd.	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	0·8	—	—	—	—	4·0	—
DYTISCIDAE																					
<i>Clypeodytes</i> sp.	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
HELODIDAE																					
Species A	5·8	3·3	1·9	0·8	1·1	—	0·2	0·5	—	—	—	—	—	—	—	—	—	—	—	—	—
Species B	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Species C	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—
HELMIDAE																					
Species 6AA larvae	0·4	4·0	0·8	1·2	1·1	2·1	6·8	3·0	0·6	6·4	8·2	0·9	8·0	—	0·8	—	—	2·0	1·0	—	—
Species 230C	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—
CHIRONOMIDAE																					
*Unsorted	2·3	1·3	10·8	—	3·6	55·8	25·3	0·5	4·0	8·4	24·2	0·7	15·0	—	21·8	—	5·0	11·5	23·7	21·0	—
LEPTIDAE																					
<i>Atherix</i> spp.	—	<i>p</i>	<i>p</i>	—	—	—	<i>p</i>	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—

* These continue on soft bottoms in the zone below. ¹ Based on October samples only. ² Not sampled. ³ Based on February samples only.

⁴ Based on April samples only. ⁵ Based on July sample only.

Table 19. Figures in columns show percentage incidence in samples; *p* means: present in small numbers throughout the season. S S A W: Spring, Summer, Autumn, Winter. A dash indicates that a species was absent; blank columns indicate that no sample was taken.

were recorded at Station 1 in spring but figures were appreciable at all seasons. During the wet months they also appeared lower down at Station 3. *Centropilum excisum* took the place of *Pseudocloeon*-sp. A. in Zones IIIA and IIIB. Incidences were at their highest in Zone IIIB during the dry months.

Leptophlebiidae. *Aprionyx peterseni* was prominent in all stony situations in Zone II, except in the strongest current, and was an important constituent of the fauna in the backwaters at all seasons, the highest incidences being reported in summer. It was also fairly prominent in the backwaters at Station 3, but practically disappeared below this point. *Aprionyx intermedius* was mainly an autumn species with the highest percentage incidences at Stations 3 and 5 where it was found in small numbers at other seasons. *Castanophlebia calida* was obviously only a stray from the runs and was only important in the backwaters at Station 1 during floods. *Choroterpes nigrescens* was mainly characteristic of Zone IIIA, especially Station 3. Incidences were usually low except at Station 3 in spring. *A. tabulans* was a species of Zone IIIA.

EphemereUidae. *Lithogloea harrisoni* was mainly a species of Zone IIIA where the highest percentage incidences were recorded in winter and spring. However, it moved up to Station 1 in appreciable numbers in summer and autumn. *Lithogloea pennicillata* occurred in all stony habitats in Zone II but mainly in the current; high incidences were recorded from backwaters during the winter flood period. Apart from winter months, incidences were insignificant in Zone IIIA and below.

Caenidae. *Austrocaenis* sp. was very abundant in the backwaters at Stations 9 and 10 in spring. At this time there was a fair amount of mud deposited between the stones. The disappearance at Station 10 in the summer might have been linked with the high temperatures reported there (37° C.).

Anisoptera. Nymphs of *Trithemis* spp., most of them small, appeared in some numbers in the backwaters at Stations 9 and 10 during autumn.

Corixidae. The one high incidence of *Micronecta piccanin* was recorded from Station 5 in autumn. However, there were often large numbers at the extreme margins of pools and backwaters from Station 5 down, but these fringes were not normally sampled.

Sericostomatidae. *Petroplax* spp., though few in number, were characteristic of backwaters at Stations 3 and 5 during spring.

Leptoceridae. Larvae of the '*Leptocerus scramasax*' type (Barnard 1934 A) showed their highest seasonal percentage incidence at Station 5 in winter but were fairly common there during all seasons. They were also common at Station 1 in autumn and winter and fairly common at Station 3 in winter. *Athripsodes* sp. B., which has a spiral case, rather like *Helicopsyche*, could always be found in backwaters at Stations 3 and 5 during summer but it was more common in sheltered spots among stones at the margins of stickles.

Polycentropidae. Larvae, apparently *Protodipseudopsis*, were always present in backwaters at Station 5 and sometimes at Stations 3 and 9. Though not numerous, their fairly large size made them easy to spot.

Hydroptilidae. Larvae of *Hydroptila capensis* were usually to be found in backwaters during the dry season associated with *Spirogyra*.

Helodidae. Larvae of Species A were common at Station 1 in spring and summer, but normally they favoured stones in the current.

Helmidae. Larvae of Species 6AA were fairly common in Zone IIIA during summer and autumn and also at Station 9 in spring.

Chironomidae. Incidences were very low in winter but rose in spring, and a very high incidence was recorded at Station 3 in summer.

Samples taken with a fine net in autumn at Stations 9 and 10 showed that there was a large population of smaller animals present in addition to those dealt with above. These were mainly small Ostracoda and *Cyclops* spp., though there were a few *Hydra* sp., small Planarians, *Macrothrix* sp., *Acroperus* sp., and *Chydorus* sp. (all Cladocera); all of these would have been swept away with the first winter flood.

(d) *Fauna of Soft Bottoms* (Tables 20 to 22)

Soft bottoms in Zone III, represented in Table 20 by Stations 3 and 9, were only sampled occasionally, but from Station 12 down, regular monthly samples were taken except during winter floods.

The composition of soft bottoms was not the same at all stations; at most they consisted mostly of sand, but in Zone IV there was sometimes a small admixture of mud and at Stations 18 and 19 always a large amount of fine vegetable detritus. The bottoms at Stations 14 and 21 were always muddy, and at Station 13 (Hermon) they were muddy during the wet months. In Table 20 the type of bottom is indicated.

Table 20 shows that samples from soft bottoms were not rich in species. Muddy bottoms were characterized by the presence of Lumbricidae with Sphaeridae (*Pisidium costulosum* Conn.) in the upper parts of Zone IV. Chironomidae, mainly Chironominae, were usually present in sandy bottoms in large numbers, and Gomphinae (*Paragomphus cognatus*) and Baetidae were common in and on them. Corixidae (*Micronecta* spp.) were always present during the dry months, along the shallow fringes.

Ceratopogonidae were a feature of Stations 18 and 19 but were also found at Station 12; however, most of them must have passed through the coarse net used. A truer picture of the associations of settled sandy bottoms will be given in Part 2 of this series.

During winter floods the fauna of soft bottoms was greatly reduced in number and variety.

Sandy and muddy bottoms have been dealt with separately in the following descriptions of species distribution:

(i) *Fauna of Sandy Bottoms* (Table 21)

The sandy bottoms sampled were those of backwaters well open to the main river, or of quiet sections of the bed where the current was not strong enough to disturb the bottom.

TABLE 20. DISTRIBUTION OF SPECIES OF MAIN GROUPS ON SOFT BOTTOMS

GROUP	3		9			12				13				14				16				18				19				21			
	S	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W
Hydra							<i>p</i>					<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>			<i>i</i>								<i>i</i>	<i>i</i>	<i>i</i>			
Prostoma												<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>											<i>i</i>	<i>i</i>	<i>i</i>			
Nematoda												<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>												<i>i</i>	<i>i</i>	<i>i</i>			
Sphaeriidae												<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>												<i>i</i>	<i>i</i>	<i>i</i>			
Lymnaeidae							<i>i</i>	<i>i</i>																									
Naididae			<i>i</i>			<i>2</i>								<i>2</i>	<i>i</i>																		
Tubificidae															<i>i</i>	<i>i</i>						<i>i</i>	<i>i</i>										
Enchytraeidae		<i>i</i>																															
Lumbricidae						<i>i</i>		<i>i</i>		<i>3</i>		<i>2</i>		<i>2</i>	<i>2</i>	<i>i</i>	<i>i</i>	<i>i</i>				<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>				
Polychaeta																										<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>				
Cladocera						<i>i</i>	<i>2</i>	<i>2</i>		<i>2</i>	<i>2</i>				<i>i</i>	<i>i</i>		<i>i</i>	<i>2</i>				<i>i</i>			<i>2</i>	<i>2</i>						
Ostracoda																																	
Bactidae		<i>i</i>	<i>2</i>			<i>i</i>	<i>2</i>	<i>2</i>	<i>2</i>	<i>i</i>	<i>i</i>	<i>i</i>	<i>2</i>					<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>	<i>i</i>	<i>2</i>		<i>i</i>	<i>i</i>	<i>i</i>	<i>2</i>				
Caenidae	<i>i</i>	<i>i</i>	<i>i</i>			<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>									
Zygoptera							<i>i</i>																<i>i</i>										
Anisoptera	<i>i</i>		<i>2</i>	<i>i</i>		<i>i</i>	<i>2</i>	<i>2</i>	<i>i</i>	<i>i</i>	<i>2</i>	<i>i</i>		<i>i</i>	<i>i</i>	<i>i</i>		<i>i</i>	<i>2</i>	<i>i</i>	<i>i</i>	<i>i</i>	<i>2</i>	<i>2</i>		<i>i</i>	<i>2</i>	<i>i</i>	<i>i</i>				
Corixidae			<i>i</i>	<i>i</i>		<i>2</i>	<i>2</i>	<i>3</i>		<i>2</i>	<i>2</i>			<i>i</i>		<i>i</i>		<i>i</i>	<i>2</i>			<i>3</i>	<i>3</i>			<i>4</i>	<i>3</i>						
Leptoceridae	<i>i</i>	<i>2</i>	<i>2</i>																														
Polycentropidae			<i>i</i>	<i>i</i>																													
Hydroptilidae														<i>i</i>								<i>i</i>											
Dytiscidae						<i>i</i>		<i>i</i>											<i>i</i>				<i>i</i>										
Hydrophilidae																			<i>i</i>														
Dryopidae		<i>i</i>																															
Helmiidae	<i>i</i>	<i>i</i>	<i>i</i>																														
Chironomidae	<i>p</i>	<i>p</i>	<i>p</i>			<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>				
Ceratopogonidae							<i>i</i>	<i>i</i>				<i>i</i>											<i>i</i>	<i>i</i>			<i>i</i>	<i>i</i>					
Simuliidae							<i>p</i>											<i>p</i>	<i>p</i>			<i>p</i>											
Tadpoles	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>m</i>	<i>ms</i>	<i>s</i>	<i>s</i>	<i>m</i>	<i>m</i>	<i>m</i>	<i>m</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>ms</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>	<i>s</i>				

s—sand *m*—mud *ms*—mixed sand and mud
 TABLE 20. Numbers in the columns indicate the number of species which could be distinguished.
 Chironomidae were usually present but it was not possible to sort larvae and pupae to species.

The numbers of samples from Stations 3 and 9 were inadequate for derivation of percentage incidence figures, and so these stations have not been included in Table 21. As there was very little winter sampling there is no column, but the few samples taken indicated that scouring during floods removed most animals. Those remaining were mainly Lumbricidae or Chironomidae.

The samples considered here were all taken by hand-net (see Methods) which was swept vigorously over the bottom, this was disturbed at the same time to a depth of about $\frac{1}{2}$ to 1 inch. Thus both the surface dwellers, such as *Centroptilum excisum*, and those in the top layer, such as the Chironomidae, were taken. The samples only included those animals which would be retained by the 23 mesh/inch bolting silk net. Quantitative samples taken with a Birge-Ekman grab and washed through a finer net will be dealt with in Part 2 of this series.

Oligochaeta. The high seasonal incidence of *Nais* sp. at Station 12 in spring seemed to be linked to slight organic pollution there. Incidences of Lumbricidae in sandy bottoms were not normally high. Exceptions, apparent from the tables, were due to abnormally high admixture of mud. For instance, at Station 13 in spring the net passed through patches of pure, freshly deposited mud. As the river receded in summer much of the mud was left behind on dry banks and only the clean sand was submerged, and the numbers of Lumbricidae dropped off. *Tubifex* sp. were quite common at the lower stations in autumn; however, there were no other signs of pollution there.

Cladocera. Both *Simocephalus vetuloides* and *S. capensis* showed highest incidence in summer, the latter mainly higher up the river.

Baetidae. *Centroptilum excisum* was most characteristic of sandy bottoms where the flow was slow or negligible. Incidences were generally highest in autumn. *Centroptilum pulchrum* was fairly common at Station 12 in summer, otherwise it was insignificant.

Caenidae. The highest incidence of *Austrocaenis* sp. generally was in summer and there was a distinct falling-off in autumn which began before any flooding occurred.

Anisoptera. *Paragomphus cognatus* was very typical of settled sandy bottoms and was most noticeable because of its size and the tracks it left in the sand. The high percentage incidence for spring at Stations 18 and 19 were recorded when the fauna was very sparse. *Trithemis* spp. nymphs were commonest at all stations in summer and there was a general falling-off in autumn.

Coroxidae. *Micronecta piccanin* was the most widespread species in the river and showed its highest incidences at Station 12 in the summer and at Station 19 in autumn. *Micronecta bleekiana* was always present at Station 21 (see section on marginal vegetation) and appeared in fair numbers at Stations 18 and 19 in summer. In autumn it spread right up to Station 12, by which time it was the commonest species in Zone IV. Winter floods practically eliminated it except in Zone V. *Micronecta scutellaris* was widespread in summer and autumn but numbers were not so high as those of the previous two species. *Micronecta winifreda* appeared in small numbers at Station 19 during the summer months.

TABLE 21. SIGNIFICANT ANIMALS FROM SANDY BOTTOMS

	IIIB			IV											
	S.	12 S. %	A. %	S.	13 S. %	A. %	S.	16 S. %	A. %	S.	18 S. %	A. %	S.	19 S. %	A. %
HYDRIDAE															
<i>Hydra</i> sp.	—	—	p	—	—	—	—	—	—	—	—	—	—	—	—
NEMERTINI															
<i>Prostoma</i> sp.	—	—	—	—	—	p	—	—	p	—	—	—	—	—	—
LYMNÆIDAE															
<i>Ferrissia</i> sp.	—	—	p	—	—	—	—	—	—	—	—	—	—	—	—
OLIGOCHAETA															
<i>Nais</i> sp.	22.4	—	0.8	—	—	0.4	0.9	—	—	—	—	—	—	—	—
<i>Slavina appendiculata</i>															
Udek.	1.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Tubifex</i> sp.	—	—	—	—	—	0.7	—	—	—	—	0.7	13.6	—	p	6.9
<i>Lumbriculus</i> sp.	—	—	—	57.8	—	—	8.0	—	—	32.0	—	0.4	—	—	—
Lumbricids, medium	0.1	—	—	34.3	—	—	—	—	—	—	p	—	—	—	—
Lumbricids, large	—	—	—	p	—	—	—	—	—	—	—	—	—	—	—
CLADOCERA															
<i>Simocephalus vetuloides</i>															
G. O. Sars.	0.9	8.4	0.4	—	14.0	—	—	2.4	0.9	—	1.2	—	—	13.8	0.5
<i>Simocephalus capensis</i>															
G. O. Sars.	—	15.5	0.9	—	16.8	—	—	—	0.4	—	—	—	—	0.1	0.3
OSTRACODA															
<i>Cypricercus</i> sp.	—	—	—	—	p	—	—	—	—	—	—	—	—	—	—
<i>Cypria</i> sp.	—	—	—	—	p	—	—	—	—	—	—	—	—	—	—
<i>Pionocypris</i> sp.	—	—	—	—	p	—	—	—	—	—	—	—	—	—	—
BAETIDAE															
<i>Centropilum excisum</i>															
Brnrd.	50.5	8.7	13.4	1.5	14.0	9.5	6.9	2.4	3.0	32.0	1.2	8.7	—	13.8	19.6
<i>Centropilum pulchrum</i>															
Crass.	—	6.4	1.4	—	—	—	—	—	—	—	—	0.1	—	—	—
CAENIDAE															
<i>Austrocaenis</i> sp.	0.8	4.4	2.7	0.1	20.6	—	7.1	5.8	0.1	16.0	19.6	0.1	—	4.7	0.3
ZYGOPTERA															
<i>Pseudagrion</i> spp.	—	p	—	—	—	—	—	—	—	—	p	—	—	—	—
ANISOPTERA															
<i>Paragomphus cognatus</i>															
(Rambur)	0.8	2.5	14.9	—	11.8	27.0	0.9	17.0	3.8	16.0	6.9	5.1	25.0	0.2	0.1
<i>Trithemis</i> spp.	—	1.8	1.5	p	1.0	—	—	6.7	—	—	4.3	0.4	—	0.4	—
CORIXIDAE															
<i>Micronecta piccamin</i>															
Hutch.	1.6	16.8	1.0	—	1.8	—	—	—	4.7	—	0.4	4.9	—	5.8	12.7
<i>Micronecta bleekiana</i>															
Hutch.	—	—	4.1	—	—	9.5	—	—	73.7	—	8.1	25.8	—	20.9	22.7
<i>Micronecta scutellaris</i>															
Hutch.	0.5	2.5	10.1	—	3.2	2.4	—	0.4	—	—	p	6.2	8.0	0.8	3.0
<i>Micronecta winifredi</i>															
Hutch.	—	—	—	—	—	—	—	—	—	—	—	—	—	p	—
HYDROPTILIDAE															
<i>Hydroptila capensis</i>															
Brnrd.	—	—	—	—	—	—	—	p	—	—	p	—	—	—	—
DYTISCIDAE															
<i>Tola harrisoni</i> O.-C.	p	—	p	—	—	—	—	—	p	—	—	p	—	—	—
CHIRONOMIDAE															
Unsorted	14.7	30.7	38.3	2.5	12.1	25.8	35.8	47.6	8.8	p	43.9	29.2	50.0	50.6	31.9
CERATOPOGONIDAE															
<i>Nilobezzia capensis</i>															
de M.	—	p	0.8	—	—	0.7	—	—	0.7	—	2.3	4.4	—	0.7	0.1

Table 21. Figures in columns show percentage incidence in samples, 'p' means: present in small numbers throughout the season. S, S, A: Spring, Summer, Autumn; no winter samples were taken.

Dytiscidae. *Yola harrisoni* occurred occasionally on sandy bottoms or in sheltered margins in Zone IV and at Station 12. It was most common in autumn.

Chironomidae. From Stations 16 to 19 incidences were highest in summer, and from Stations 13 and 14 in autumn. Quantitative studies will be dealt with in Part 2 of this series.

Ceratopogonidae. *Nilobezzia capensis* was most widespread in autumn when incidences were highest at Station 18. Many must have passed through the mesh of the net, and a better picture of their distribution will be obtained from the Birge-Ekman grab studies in Part 2 of this series.

(ii) *Fauna of Muddy Bottoms* (Table 22)

Muddy bottoms were sampled sometimes with a Birge-Ekman grab and sometimes by scooping up mud with a stout hand-net. Both the grab and the hand-net always went through the mud layer and collected a large amount of the coarse sand and gravel underneath. There was always a certain amount of vegetable detritus, mainly leaf and twig remains, mixed with the mud, and at Station 14 this usually formed a large part of the bulk of the material brought up.

TABLE 22. SIGNIFICANT ANIMALS FROM MUDDY BOTTOMS

	SPRING		SUMMER		AUTUMN		WINTER	
	IV	V	IV	V	IV	V	IV	V
	14	21	14	21	14	21	14	21
	%	%	%	%	%	%	%	%
NEMERTINI								
<i>Prostoma</i> sp.	21.0	2.8	2.3	8.8	23.0	10.4	13.2	
SPHAERIDAE								
<i>Pisidium costulosum</i> Con.	5.6		1.7		2.3			
POLYCHAETA								
<i>Ceratonereis keiskama</i> Day		3.6				1.2		3.2
<i>Polydora</i> sp.						17.9		4.0
OLIGOCHAETA								
<i>Nais</i> sp.			1.8		4.1			
<i>Slavina appendiculata</i> Udek			10.9					
Lumbricid, medium	<i>p</i>		1.0					
<i>Lumbriculus</i> sp.	60.3	85.4	67.1	74.5		16.8	37.4	78.8
Enchytraeidae?				13.9				
<i>Tubifex</i> sp.					9.7	6.1	4.8	
CLADOCERA								
<i>Simocephalus capensis</i> G. O. Sars					13.9		0.6	
ANISOPTERA								
<i>Trithemis</i> spp.	0.7		0.8		8.0			
CORIXIDAE								
<i>Micronecta piccanin</i> Hutch.	2.0				9.1	21.1	0.6	0.2
<i>Micronecta bleekiana</i> Hutch.						4.8		1.8
<i>Micronecta scutellaris</i> (Stål.)						10.4		4.5
CHIRONOMIDAE								
Unsorted	4.1	3.3	9.8	1.4	9.1	11.2	3.3	3.8

Table 22. Figures in columns show percentage incidence in samples;
p means: present in small numbers throughout the season.

Most of the mud was washed out through 23/4 inch mesh bolting silk before the sample was dealt with in the laboratory.

Nemertini. Except for winter at Station 21 *Prostoma* sp. was always a feature of mud bottom samples.

Sphaeriidae. *Pisidium costulosum* was only found at Station 14, and, though not shown by seasonal averages, monthly incidence was very variable; sometimes there were a large number present one month and none the following, even when samples were taken in practically the same spot. Though none was present in the samples taken during the winter of 1952, used for the table, one sample taken in June 1951 contained 88 individuals, an incidence of 73%. The distribution in the river-bed must have been very irregular.

Polychaeta. These were estuarine in origin. *Ceratonereis keiskama* was the least numerically important of the two and appeared in spring, whereas *Polydora* sp. appeared in autumn and winter.

Oligochaeta. *Nais* sp. was only found at Station 14 during summer and autumn. *Slavina appendiculata* occurred at Station 14 in summer. Small Lumbricidae usually dominated the samples except in autumn when incidence fell off rapidly, and they were even absent at Station 14. Small worms which appeared to be Enchytraeidae appeared at Station 21 in summer. The appearance of *Tubifex* sp. in the autumn and winter of 1952 might have been an unusual feature related to the late onset of floods which did not begin until late in July; samples taken during the normal autumn and winter of 1951 did not contain them.

Anisoptera. *Trithemis* spp. nymphs were found at Station 14 during autumn.

Corixidae. *Micronecta* spp. were generally abundant in all shallow water and marginal vegetation at Station 21 in autumn and winter. It would seem that large numbers were washed down from Zone IV during flooding.

Chironomidae. These were far less important a part of the fauna and far less numerous in the muddy bottoms than in the sandy or mixed bottoms.

When the faunas of muddy bottoms of Zone IV (Station 14) and Zone V (Station 21) are compared, it will be seen that they resemble one another in the importance of Lumbricidae and *Prostoma* sp. and in the small incidence of Chironomidae, and differ mainly in the complete absence at Station 21 of *Pisidium costulosum* and *Trithemis* spp. The presence of three species of *Micronecta* at Station 21 in autumn and winter was linked to the general abundance of these there at that time; the Polychaeta had obviously migrated up from the estuary.

The large pool formed by the barrage on the Klein Berg near Gouda had a muddy bottom similar to that at Station 14. Here, apart from Lumbricidae and abundant *Pisidium costulosum*, there were large numbers of the large flat nymphs of *Ceratogomphus pictus* and larvae of *Tanyptus guttatipennis* Goet. (Chironomidae—Tanyptodinae), neither of which was found at Station 14.

(e) *Fauna of Marginal Vegetation* (Tables 23 and 24)

Table 23 shows that faunal changes in the marginal vegetation downstream were similar to those in stones in the current. In general there were fewer species at the lower stations.

Nemouridae soon disappeared except in winter when they extended right down to Station 12 (Wellington). Baetidae were important throughout the river except in the sluggish parts. Zygoptera were practically universal except in spring. Trichoptera fell off after the Leptoceridae had reached their maximum in Zone IIIA. Clinging beetles practically disappeared at Station 5.

Important additions to the fauna in lower Zone IIIB and Zone IV were the Lymnaeidae, the Naididae and the larger Cladocera.

Chironomidae practically always formed a major part of the fauna and *Simulium* larvae were usually found on those parts of the vegetation which trailed in the current.

Table 24 gives the species distribution and seasonal changes. Some of the species are discussed below.

Lymnaeidae. *Lymnaea (Pseudosuccinea) columella*, an introduced North American species, has become established in the middle reaches of the river and was occasionally found lower down. The fairly high winter figure for Station 12 was probably due to organic pollution as, in June, snails were found feeding on resulting deposits and growths among the palmet. Most of these were washed out later in the season. The high summer incidence of *Ferrissia* sp. at Stations 12 and 14 was associated with quiet water conditions in the marginal vegetation.

Naididae. *Nais* sp. was always present in the quieter waters of Station 14, especially in summer and autumn. They were also common at Station 18 in autumn where there were many sheltered spots in the vegetation. The high incidence at Station 12 in spring was associated with mild organic pollution. *Stylaria fossularis* was characteristic of the lower stations of Zone IV and of Zone V.

Cladocera. *Simocephalus vetuloides*, like the next species, favoured quiet conditions and thus was commonest generally during the dry months although there was an earlier spring outburst in the quiet stretch at Station 14. No distribution pattern could be discerned and individual monthly figures of over 5% could be expected from any station from Stations 12 to 19. However, *S. capensis* had a higher incidence in the upper parts of its range, though there was a slight downward move in autumn.

Nemouridae. The highest percentage incidence of the nymphs of the *Aphanicercas*-*Aphanicercopsis*-*Desmonemoura* type were recorded in winter, especially at Station 1 where they formed a very important part of the fauna of the marginal vegetation. They remained a feature of the marginal vegetation in Zone II right throughout the year, but were less important lower down. The individuals present at Station 16 must have been washed down from the Twenty-four Rivers stream, a mountain stream which enters the main river just above this point (see map). *Aphanicercella* sp. nymphs were never as numerous as the previous type and reached their maximum at Station 5 in autumn.

AMPHIPODA														
<i>Chiltonia capensis</i> Brnrd.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Parocheastia rectipalma</i> Brnrd.	—	—	—	—	—	—	—	—	—	—	—	—	—	p
NEMOURIDAE														
<i>Aphanicercera</i> spp. etc.	11.9	3.3	12.1	69.0	0.4	0.6	7.2	13.6	—	—	—	16.3	—	0.8
	—	—	—	3.0	—	—	—	0.9	—	—	—	—	—	—
	—	—	—	3.9	—	—	—	—	—	—	—	—	—	—
<i>Aphanicercella</i> spp.	—	—	0.3	0.2	—	0.2	1.5	2.3	—	—	5.8	0.7	—	0.7
	—	—	—	2.1	—	—	—	—	—	—	—	—	—	—
BAETIDAE														
<i>Baetis harrisoni</i> Brnrd.	2.3	5.8	—	—	2.0	0.6	—	1.3	2.3	2.3	—	0.5	0.8	18.3
	—	0.6	—	4.4	4.8	—	—	9.8	0.1	—	—	1.7	—	0.5
	—	—	—	—	0.6	—	—	—	0.1	—	—	—	—	—
<i>Baetis bellus</i> Brnrd.	—	—	—	—	—	—	—	—	2.8	34.1	4.0	—	1.3	7.0
	0.2	29.5	49.8	0.4	28.8	30.8	10.9	0.8	62.9	63.0	35.5	10.8	9.1	0.6
	19.9	21.7	54.2	19.2	26.7	31.7	9.2	11.2	31.9	30.4	31.6	3.4	7.1	11.8
<i>Baetis</i> sp. B	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	0.1	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	2.6
	—	—	—	—	10.0	1.9	1.1	6.1	6.6	—	—	3.4	5.2	0.2
<i>Pseudocloeon vinosum</i> Brnrd.	35.6	23.0	17.3	5.2	47.0	18.7	12.7	32.7	49.8	21.9	3.3	53.3	82.7	20.4
	84.3	8.2	26.3	68.9	44.9	—	15.6	12.9	1.9	0.4	9.1	43.7	0.6	—
	23.9	0.1	6.8	48.4	33.4	—	0.9	47.7	20.1	—	4.8	43.1	2.2	—
<i>Centroptilum sudafricanum</i> Til.	3.6	2.1	—	—	—	—	—	—	0.1	—	—	—	—	—
	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Centroptilum excisum</i> Brnrd.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	0.8	0.1	0.4	0.2	2.1	1.8	1.9	—	2.9	2.9	—	—
	6.0	0.5	4.1	2.3	3.4	0.2	2.4	0.8	2.0	9.5	—	1.1	0.3	—
<i>Centroptilum pulchrum</i> Crass	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	13.5	—	—
<i>Centroptilum</i> sp. A	6.7	1.3	—	—	5.2	0.2	0.5	1.1	2.3	0.2	0.6	—	3.5	—
	—	—	—	—	p	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Austrocloeon virgiliae</i> Brnrd.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	4.2	6.7	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	4.5	—	—	—	—	—	—	—

TABLE 24 (continued)

First Row	1 10 16				3 12 18				5 13 19				9 14 21			
	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %	S %	S %	A %	W %
LEPTOPHLEBIIDAE																
<i>Aprionyx intermedius</i> Brnrd.	—	—	—	—	—	—	—	<i>p</i>	<i>p</i>	—	—	—	—	—	—	—
<i>Castanophlebia calida</i> Brnrd.	<i>p</i>	—	—	<i>p</i>	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—
EPHEMERELLIDAE																
<i>Lithogloea harrisoni</i> Brnrd.	—	—	—	—	<i>p</i>	—	<i>p</i>	<i>p</i>	<i>p</i>	—	<i>p</i>	<i>p</i>	—	—	—	—
<i>Lithogloea pennicillata</i> Brnrd.	<i>p</i>	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—
<i>Lithogloea</i> sp. A.	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—
CAENIDAE																
<i>Austrocaenis</i> sp.	—	—	—	—	—	—	—	<i>p</i>	—	<i>p</i>	<i>p</i>	—	—	—	—	—
ANISOPTERA																
<i>Trithemis</i> sp.	—	<i>p</i>	<i>p</i>	—	—	<i>p</i>	<i>p</i>	—	—	—	—	—	—	<i>p</i>	—	—
ZYGOPTERA																
<i>Pseudagrion</i> spp.	0·2	0·8	2·4	—	—	0·7	1·8	0·5	0·1	1·2	7·4	0·2	0·4	14·4	7·7	0·2
<i>Enallagma</i> spp.	—	10·7	2·4	3·2	—	6·0	1·2	1·3	1·5	2·2	0·4	0·3	0·8	3·1	0·2	0·9
	2·2	3·9	1·8	2·5	0·2	15·7	0·5	0·2	—	3·5	1·7	1·1	1·5	10·4	1·4	2·4
	—	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—
NOTONECTIDAE																
<i>Anisops aglaia</i> Hutch.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<i>p</i>	—
<i>Nychia limpida</i> (Stål.)	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	1·2	6·1	0·6	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	12·4	0·2	1·3	—	5·5	12·1	1·0	—

TABLE 24 (continued)

First Row Second Row Third Row	1 10 16			3 12 18			5 13 19			9 14 21		
	S	A	W	S	A	W	S	A	W	S	A	W
	%	%	%	%	%	%	%	%	%	%	%	%
PSYCHOMYIDAE												
<i>Econurus</i> sp.												
HYDROPTILIDAE												
<i>Hydroptilia capensis</i> Brnrd.	p							p				
<i>Argyrobothrus velocipes</i> Brnrd.	13.6	7.4										
	0.5	3.3		0.3	1.0	0.5	0.6	0.9		19.3	0.5	
	0.4	0.6			0.1			p		7.9		
Hydrotilid 'caraway seed'	p						0.2			25.8		
										0.3		
HYDROPHYLLIDAE												
<i>Hydroctus gemmatus</i>												
<i>Berosus</i> sp.											p	
<i>Helochaetes</i> sp.												
<i>Paracyamus</i> sp.												
HYDRAENIDAE												
Species 6Y	p											p
Species 8K												
Species 239F												p
HELODIDAE												
Species A												

Species C	1.1	—	—	9.7	0.2	—	7.2	10.5	—	—	0.8	0.1	—	—	—	—
HELMIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Species 6AA (larvae)	—	—	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	—	—	—	<i>p</i>	—	—	—	—	—
Species 8J (larvae)	—	—	—	—	<i>p</i>	<i>p</i>	—	<i>p</i>	—	—	—	—	—	—	—	—
GYRINIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Aulonogyrus</i> larvae	—	—	—	—	<i>p</i>	—	—	<i>p</i>	—	—	—	—	—	—	—	—
TIPULIDAE	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—
<i>Limonia tipulipes</i> (Karsch)	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CULICIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Culex</i> sp.	—	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—
DIXIDAE	—	1.3	0.2	—	1.4	5.6	4.9	—	6.7	0.2	0.2	—	0.3	—	—	—
<i>Dixa</i> sp.	0.4	—	0.3	—	0.3	—	—	0.3	—	—	—	0.3	—	—	—	—
CHIRONOMIDAE	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unsorted	0.6	25.3	24.0	0.4	3.5	16.3	5.2	1.7	9.2	4.2	15.7	0.8	2.8	14.1	8.4	0.9
	1.6	18.1	2.5	3.2	6.4	16.1	19.5	48.4	20.4	10.5	24.2	1.0	15.8	6.1	4.8	21.0
	16.5	52.6	9.5	7.1	15.7	24.7	25.2	18.5	10.8	26.9	6.4	32.7	2.9	—	1.3	4.0
CERATOPOGONIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Nilobezzia capensis</i> de M.	—	—	—	—	—	—	<i>p</i>	—	—	—	—	—	—	—	—	—
SIMULIIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unsorted	22.6	2.9	1.4	4.2	12.9	30.1	10.4	13.2	7.8	15.2	1.0	14.8	0.5	10.5	4.6	6.2
	6.8	4.0	2.3	4.8	3.3	0.2	6.3	10.3	0.1	5.7	12.4	—	—	—	0.2	0.5
	—	0.4	8.3	0.2	—	—	3.7	8.1	0.6	—	7.7	3.4	—	—	—	—
LEPTIDAE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Atherix</i> spp.	<i>p</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 24. Figures in columns are the average percentage composition for the month; *p*: present in small numbers in two-thirds or more of the monthly samples. The stations fall into the following zones: Zone II: Station 1; Zone IIIA: Stations 3 and 5; Zone IIIB: Stations 9, 10 and 12; Zone IV: Stations 13, 14, 16, 18 and 19; Zone V: Station 21. S S A W: Spring, Summer, Autumn, Winter.

Baetidae. This family showed a distinct distribution pattern with seasonal variations. *Baetis harrisoni* typical of stones in current, only occurred in appreciable numbers in the marginal vegetation during the winter and spring flood periods. *Baetis bellus*, a true vegetation species, first appeared at Station 5 and extended right down to Station 21. Low incidence in the quiet stretches at Stations 14 and 21 indicated that it preferred vegetation bathed in flowing water; however, incidences were generally low in winter when conditions were severe. Low winter temperatures may also have had something to do with the reduced numbers. In spring, when current conditions became milder and temperatures rose, there was a distinct movement upstream to Station 5 where it thrived in summer. *Baetis* sp. B. was never as numerous as *B. bellus* and was limited mainly to the lower parts of Zone IV and to Zone V. Like the previous species it preferred conditions of mild water movement; highest incidences were recorded in spring.

Pseudocloeon vinosum, another vegetation dweller, was especially characteristic of vegetation which was well washed by the current. As the flow dropped, during the dry season, it became much scarcer in the lower zones and was only found on pieces of clean trailing vegetation. Mud deposits on the vegetation would appear to be a limiting factor as it was still found in Zone II and Zone IIIA in summer where the vegetation was always perfectly clean; lower temperatures in these upper zones might have assisted it to multiply in conditions which were otherwise not optimal.

Centroptilum sudafricanum was of very limited importance in the Great Berg and appeared to be at the end of its geographical range, as in rivers to the north-east it is much more abundant and not limited to marginal vegetation. The very low pH in Zone II may have been an adverse factor. *C. excisum* is largely a species of sandy backwaters but was sometimes found in the vegetation in fair numbers, especially in winter. *Centroptilum pulchrum* was only of importance in winter samples from Station 13. It was usually a species of soft bottoms and unstable flooding conditions may have led to its appearance in vegetation. *Centroptilum* sp. A. was common at Stations 1 and 3 in spring. It was far more numerous in *Scirpus digitatus* where this grew in rather quiet current conditions.

Austrocloeon virgiliae appeared at Station 10 in summer and at Stations 10 and 12 in autumn; it is a species of still or slow flowing water.

The Leptophlebiidae and Ephemerellidae, shown on the tables, were strays from other habitats, mainly in times of flood in the upper zones.

Zygotera. Nymphs of *Pseudagrion* spp. were at their commonest in summer in all zones. They were probably nearly all nymphs of *P. kersteni* var. *draconis* Barnard, which was very common along the whole river.

Notonectidae. The appearance of *Anisops aglaia* at Stations 14 and 16 in the autumn of 1952 was due to a large inflow of water from Voëlvelei which carried it down (see section on chemical analysis); it is not a riverine species. *Nychia limpida* tended to collect in the deeper pools under the banks and was caught if the vegetation sampled fringed such a pool. This was the case at Stations 12 and 21 and also at Station 19 in spring; it was not taken elsewhere.

Naucoridae. *Laccocoris limnogenus* was characteristic of vegetation samples taken at Station 18 to 21, especially in autumn. Though few in number it was conspicuous because of its relatively large size.

Corixidae. *Micronecta* spp. were normally found along the extreme sandy margins but were also found among vegetation, especially at Station 21 where margins unfringed with vegetation were very limited and very muddy; here figures for *M. piccanin* were very high from spring to autumn. Except for this species, which was found in numbers right up to Station 5, the group was mainly limited to Zones IV and V and was not prominent in winter. (See previous section for distribution on sandy bottoms.)

Sericostomatidae. The highest seasonal percentage incidences of *Barbarochthon brunneum* were recorded from Stations 1 and 3, especially during spring, summer and autumn. Below Station 3 the species fell off rapidly.

Leptoceridae. Larvae of the '*Leptocerus scramasax*' type were most common in autumn at Stations 1, 3 and 5. There was a big drop in winter when they were not recorded from Station 1 at all. (See section on stony backwaters.) Though occasional specimens of *Athripsodes harrisoni* were recorded right down to Station 19 they were only of numerical importance from Stations 5 to 10. *Athripsodes* sp. A. was practically limited to Zone IIIA and was only numerous at Station 5 in autumn. *Athripsodes* sp. B. appeared in small numbers in the palmiet at Station 5 in autumn. (See section on stony backwaters.)

Psychomyiidae. Larvae of *Ecnomus* sp. appeared in small numbers at Station 16 in summer and occasionally at other stations, from 12 to 19. None was bred out, so the species was not determined.

Hydroptilidae. Larvae of *Argyrobothrus velocipes* had a patchy distribution. Apart from the high spring incidence at Station 14 the highest figures were obtained in summer. It would appear that they could thrive in any zone where conditions were suitable: these seemed to include a slow flow and a certain amount of algal growth.

Helodidae. Sp. C. was found to be characteristic of submerged vegetation in Zones II and IIIA. It first appeared in the marginal vegetation in autumn, notably at Station 3, but the highest incidences were found in winter. Early instars were found in *Scirpus digitatus* in summer.

Dixidae. The highest recorded incidences of *Dixa* sp. were from Zone IIIA in spring, summer and autumn.

Chironomidae. Highest percentage incidences were obtained in summer and autumn. No attempt was made to sort these larvae, though they appeared to be mainly Chironominae. Orthocladiinae, however, appeared to be common in winter and spring when the flow was strong, especially in Zones IIIA and IIIB, and were abundant at Station 12 in winter where organic pollutants were present.

Simuliidae. Larvae of *Simulium* spp. were nearly always numerous on marginal vegetation which trailed in the current. Incidences were usually fairly high in Zones II and III where there was a lot of this trailing fringe. In Zone IV they were really

only of significance in the autumn when the main species was *S. bovis*, which was restricted to this zone. In a later paper the zonation of species will be dealt with.

(f) *Fauna of Bottom Vegetation (Scirpus digitatus)* (Tables 25 and 26)

Over the greater length of the river there is no bottom vegetation, but in Zones II and IIIA, as well as in the cliff waterfalls, there were patches of *Scirpus digitatus*; these were especially large at Station 3 where they were sampled regularly.

Table 25 summarizes the results of regular sampling at Station 3 and also the results of less complete sampling in Zone II (above Station 1) and at Station 5.

TABLE 25. DISTRIBUTION OF SPECIES OF MAIN GROUPS IN SCIRPUS DIGITATUS

GROUPS	ZONE II		3				5	
	S.	S.	S.	S.	A.	W.	S.	S.
Naididae							1	
Enchytraeidae?			1					
Nemouridae			1	2	4	2		
Baetidae		2	2	2	2	2	2	2
Ephemerellidae	3		2	2	1	3	3	
Caenidae					1			
Zygoptera					1			
Anisoptera					1			
Sericostomatidae	1	1	1	1	1	1	1	
Leptoceridae	2	1	1	2	1	1	2	2
Philopotamidae				1				
Hydropsychidae	2	2		1				
Polycentropidae			1					
Hydroptilidae	1			1	1			1
Pyralidae				1	1			
Hydraenidae	1						1	
Helodidae			1	2	2	2		
Dryopidae	2	2	2	2	2		2	1
Helmidae	1		1	4	1	1	1	1
Gyrinidae (Larvae)		p		p				
Chironomidae	p		p	p	p	p	p	p
Simuliidae	p		p	p	p	p	p	p
Leptidae				1				

Table 25. Only spring and summer records were available for Zone II and Station 5. Numbers in the columns indicate the number of species which could be distinguished. A *p* indicates that a group was present but could not be sorted to species.

The most prominent groups were Baetidae, Ephemerellidae, Trichoptera, especially Leptoceridae, Dryopidae, Helmidae, Chironomidae and Simuliidae. There was a general falling-off of the number of species at Station 5, especially in summer.

Hydracarinae were present but were missed as the net was too coarse for them; they were discovered in later samples taken with a finer net.

Table 26 deals with the species composition of the fauna at Station 3. This habitat differed from marginal vegetation in that *S. digitatus* is a true, submerged aquatic plant, and also in that parts sampled were consistently in the main current of the runs or stickles; however, the fauna was very similar. Those common to both habitats at this station were: the nymphs of the *Aphanicerca* group, with differences in

percentage incidence, *Pseudocloeon vinosum* with lower incidences in the *S. digitatus* in the winter months but much the same at other times, *Barbarochthon brunneum*, with lower incidences in the *S. digitatus* except in winter, Helodid sp. C. larvae, Chironomidae, though species composition was probably different, and Simulium larvae.

TABLE 26. SIGNIFICANT ANIMALS FROM SCIRPUS DIGITATUS (STATION 3)

	Spring %	Summer %	Autumn %	Winter %
ENCHYTRAEIDAE?				
Unidentified	<i>p</i>			
NEMOURIDAE				
<i>Aphanicera</i> group	0.1	4.4	3.6	4.1
BAETIDAE				
<i>Baetis harrisoni</i> Brnrd.	0.1	0.4	0.9	9.9
<i>Pseudocloeon vinosum</i> Brnrd.	47.4	22.3	13.6	12.7
EPHEMERELLIDAE				
<i>Ephemerellina barnardi</i> Lest.	1.0	1.3		2.7
<i>Lithogloea</i> sp. A	6.3	3.1	9.4	10.8
<i>Lithogloea pennicillata</i> Brnrd.				<i>p</i>
CAENIDAE				
<i>Austrocaenis</i> sp.			<i>p</i>	
ANISOPTERA				
Libellulid, uncorrelated			<i>p</i>	
ZYGOPTEA				
<i>Pseudagrion</i> sp.			<i>p</i>	
SERICOSTOMATIDAE				
<i>Barbarochthon brunneum</i> Brnrd.	4.2	1.7	7.7	5.7
LEPTOCERIDAE				
<i>Athripsodes schoenobates</i> (Brnrd.)	9.3	6.8	8.3	35.1
<i>Athripsodes</i> sp. D		<i>p</i>		
PHILOPOTAMIDAE				
<i>Chimarra ambulans</i> Brnrd.		<i>p</i>		
HYDROPSYCHIDAE				
<i>Cheumatopsyche maculata</i> Moseley		<i>p</i>		
POLYCENTROPIDAE				
<i>Protodipseudopsis</i> sp.	<i>p</i>			
HYDROPTILIDAE				
'Caraway seed' larva		<i>p</i>	<i>p</i>	
PYRALIDAE				
<i>Paraponyx</i> type, ? <i>Nymphula</i> sp.		12.9	0.9	
HELODIDAE				
Sp. A	3.5	3.3	1.1	0.3
Sp. B		1.5	8.4	3.1
DRYOPIDAE				
<i>Strina</i> sp. 7U	<i>p</i>	<i>p</i>	<i>p</i>	
Sp. 128 A	3.9	1.9	1.4	0.3
HELMIDAE				
Sp. 6AA Larvae	0.8	1.6	7.6	0.3
Sp. 8J imagines		<i>p</i>		
Sp. 125E		<i>p</i>		
Sp. 3M		<i>p</i>		
CHIRONOMIDAE				
Unsorted	10.9	14.9	18.6	0.6
SIMULIIDAE				
Unsorted	12.4	12.6	8.6	9.3
LEPTIDAE				
<i>Atherix</i> sp.		<i>p</i>		

Table 26. Figures in columns show percentage incidence in samples; *p* means: present in small numbers throughout the season.

The last three all showed differences in the percentage incidence, especially from season to season. Helodid sp. C. larvae appeared earlier in the summer in this habitat than in the marginal vegetation, but as very early instars.

Animals practically limited to this habitat were: *Ephemerellina barnardi*, which never had a really high incidence, *Lithogloea* sp. A, *Athripsodes schoenobates* which had its highest percentage incidence in winter, Pyralid larvae, in summer mainly, and Dryopid sp. 128A. The latter small beetles were more abundant in *Scirpus digitatus* where current speeds were low and the water was deeper. Larvae of Helmid sp. 6AA were probably strays from surrounding stony habitats.

The differences between the fauna of the two types of vegetation habitats were due (1) to the greater current speeds among the *S. digitatus*. These would have eliminated such animals as the '*Athripsodes scramasax*' type of larvae with their long cumbersome cases, and would have encouraged such species as *Pseudocloeon vinosum* in the drier months when the flow was very low among the marginal vegetation; (2) to the fact that *Scirpus digitatus* was the food plant of *Athripsodes schoenobates* and the Pyralidae.

Ephemerellina barnardi and *Lithogloea* sp. A. are both current dwellers and probably found the *S. digitatus* more suitable for attachment than the near-by stones. The second species would seem to be specialized for this habitat.

G. QUANTITATIVE STUDIES

I. STONES IN CURRENT (RUNS AND STICKLES) (Tables 27 and 28)

Monthly samples usually comprised three Surbur samplings at different parts of the bed; these were added together and dealt with as described under the section on methods. Only those parts of the bed which had been permanently submerged for at least a month were sampled; these were not difficult to distinguish from recently flooded parts because of the colour of the stones and were not difficult to get at even in the wet season as samples were only taken during periods of minimum flow; usually the parts of the bed sampled were those permanently submerged at all times of the year.

TABLE 27. NUMBERS OF ANIMALS IN STONES IN CURRENT: SEASONAL AVERAGES

Zone	Station	Spring	Summer	Autumn	Winter	Spring	Summer
		1951 per sq. met.	1951-2 per sq. met.	1952 per sq. met.	1952 per sq. met.	1952 per sq. met.	1952-3 per sq. met.
II	1	547	1,030	1,514	1,102		
	3	815	872	1,008	968		
IIIA	5	1,328	1,448	1,472	1,380		
	9	1,757	2,478	488	902		
IIIB	10	837	671	982	306		
	12			36,347	2,904	1,966	11,012
IV	18			698	282	1,344	2,009

Table 27. These are not absolute numbers but are based on samples taken with a Surbur Sampler with 23 mesh to the inch grit gauze.

Table 27 gives the average seasonal numbers for the different stations. It will be noticed that, except in spring, numbers dropped from Station 1 to Station 3. This was mainly due to the decrease of *Aprionyx peterseni* in summer and autumn and *Lithogloea pennicillata* in autumn and winter. Subsequent increases from Station 3 to 5 were mainly due to increases in the numbers of *Baetis harrisoni* at all seasons; in addition there were smaller increases of *Lithogloea harrisoni* in spring, *Cheumatopsyche maculata* in summer and autumn, *Myspoleo agilis* in winter, Helmidæ (both larvae and adults) in summer and autumn, and to a lesser degree in winter, Chironomidæ in summer and autumn, and Simuliidæ in summer, autumn and winter.

The increases in numbers at Station 9 in spring and summer over those at Station 5 were mainly due to large increases in the numbers of *Baetis harrisoni*, Chironomidæ and Simuliidæ. Decreases in autumn and winter at Station 9 and at all seasons at Station 10, were due to a general decrease of all the common species.

Station 12 presents a very special case as this station was subject to mild organic pollution which resulted in enormous increases in the population of the stony runs, especially in summer and autumn. A short description of the species involved is given in the discussion on Table 28.

At Station 18 counts were largest in spring and autumn as the species which are really numerous there (*Trichorythus discolor* and *Cheumatopsyche zuluensis*) fell off sharply in autumn and practically disappeared in winter.

TABLE 28. NUMBERS OF ANIMALS PER SQUARE METRE AMONG STONES IN CURRENT: MONTHLY AVERAGES

	Station 1	Station 3	Station 5	Station 9	Station 10	Station 12	Station 18
1951							
August		536	979	583	266		
September	529	990	1,361	925	313		
October	526	702	1,328	2,131	1,317		
November	587	752	1,296	2,214	882		
December	400	842	1,426	2,178	439		
1952							
January	1,177	839	1,501	2,534	940		
February	1,512	936	1,418	2,722	644	20,045	
March	1,721	1,368	1,267	745	562	98,990	
April	2,066	1,769	3,035	342	2,340	8,435	1,502
May	756	893	997	377	43	1,616	168
June	1,357	1,681	2,938	1,220	414	6,874	215
July	824	788	1,105	720	191	990	
August	1,127		923	767	464	850	350
September				889	263	374	393
October						5,116	2,491
November						409	1,147
December						1,751	2,177
1953							
January						789	1,583
February						30,496	2,269
March						14,612	1,523
April						432	269

Table 28. These are not absolute numbers but are based on samples taken with a Surbur Sampler with 23 mesh to the inch grit gauze.

2. MUDDY BOTTOMS (Table 29)

TABLE 29. NUMBERS OF ANIMALS IN MUDDY BOTTOMS: MONTHLY FIGURES

		Station 13 per sq. metre	Station 14 per sq. metre	Station 21 per sq. metre
1951	May		222	1,044
	June			7,305
	July			1,007
	August	405		1,066
	September			414
	October	3,196		296
	November			
	December		1,258	178
1952	January		886	
	February		958	681

Table 29. These are not absolute numbers but are based on samples taken with a Birge-Ekman grab and washed through 23 mesh to the inch grit gauze.

Zone IV. Not much quantitative sampling of muddy bottoms was done in this zone. Two samplings were made at Station 13 (Hermon) and four at Station 14 (Gouda), using the Birge-Ekman grab (Lenz modification).

In winter and spring the canal-like conditions extended right back from the Gouda region to the vicinity of Hermon so that muddy bottoms were also encountered at the latter station. The winter samples (August), taken at depths of 3 to 4 feet, contained mostly Lumbricidae ('medium-sized' 180 and 'small' 180/sq. metre) as well as a few *Austrocaenis* sp. (15/sq. metre) and Chironomidae (30/sq. metre).

The spring sample was also taken at a depth of 3 to 4 feet and showed that there had been a great increase in the mud-dwellers, mostly the Lumbricidae ('medium' 636/sq. metre and 'small' 2,072/sq. metre). Chironomidae had increased to 281/sq. metre and *Austrocaenis* sp. to 59/sq. metre; there were also some *Pisidium costulosum* (44/sq. metre).

The Gouda samples were all taken at a depth of 4 to 5 feet. Numbers in autumn were low and the fauna consisted mainly of small Lumbricids (67/sq. metre), though Chironomidae and Tipulidae (*Gonomyia* sp.) were also present (22 and 56/sq. metre respectively). No quantitative samples were taken in winter and spring as the water was too deep, but a December sampling showed that numbers had risen, due mainly to small Lumbricidae (1,123/sq. metre), though *Prostoma* sp., *Pisidium costulosum* and Chironomidae were also present (15, 74 and 46/sq. metre, respectively). The summer drop was mainly due to the falling-off of the small Lumbricidae (January 396, February 669/sq. metre), though this was slightly offset by the appearance of *Slavina appendiculata*, a mud-surface dweller (January 178 and February 112/sq. metre). Chironomidae were 178/sq. metre in January and 44/sq. metre in February.

Looking at these two adjacent stations together it would appear that there was a spring rise and a late summer and autumn fall in total numbers. This was confirmed by the total numbers in the regular, monthly, qualitative samples which gave a relative picture.

Zone V. At Station 21 quantitative samplings were done more regularly.

In May 1951 only *Micronecta* spp. appeared in the samples and no true mud-dwellers, in spite of the fact that grab samples were taken at about 4 feet to ensure that the bottoms sampled had not just been submerged a short time before. Qualitative samples, taken in May 1952, showed a very similar condition when there were very few mud animals and none of the small Lumbricidae which normally constituted at least 80% of the sample. In June 1951 there was a sudden outburst of these small Lumbricidae (4,910/sq. metre) and a number of the estuarine *Ceratonereis keiskama* appeared (890/sq. metre), the rest were *Micronecta* spp. These latter disappeared from the samples in July and the numbers of small Lumbricidae fell off to 800/sq. metre. This decline continued until December, when there were only 74/sq. metre, though numbers recovered in February to 636/sq. metre. Qualitative samplings showed that this was only temporary and that there was a rapid autumn decline until they were not found at all in May.

Other animals which occurred sometimes in appreciable numbers were: Chironomidae in July (104/sq. metre) but not at other times; and *Polydora* sp. in August (104/sq. metre). (See Table 22 for seasonal incidence figures.)

It is fairly certain that population increases in these muddy bottoms were linked with the deposition of fresh mud and vegetable detritus which came down in soil run-off. At Station 21 much was deposited during late May and June 1951, due to fairly heavy local rains; later winter rains deposited far less as there was a very high proportion of clean mountain water in the river. Deposition of mud and detritus was probably much slower at the upper stations, and the population rise only occurred in spring.

The sudden appearance of small Lumbricidae in the mud at Station 21 in June 1951 would suggest that they may have migrated from among the roots of the reeds on the banks.

Quantitative, fine-net studies of sandy bottoms are to be dealt with in Part 2 of the series.

H. MAIN FAUNAL FEATURES OF THE ZONES: A SUMMARY

ZONE I

Cliff Waterfalls. The variety was poor and numbers low. There were few Ephemeroptera (*Lithogloea* sp.), and Trichoptera were limited. Hydraenidae, Helmidae and Dryopidae were a feature. *Simulium medusaeformis* was present, Chironomid larvae were common and there were a few Ceratopogonidae.

Sponge Areas. The variety was poor but Gammaridae were very numerous, especially *Paramelita nigroculus*. Ephemeroptera were lacking and Trichoptera very limited. The rest of the fauna was mostly Helodid larvae, Simuliidae (including *Cnephia* sp.) and Chironomidae.

ZONE II

A highly varied fauna appeared mainly of: Nemourini; all Berg River families of Ephemeroptera, except Caenidae, especially characteristic Ephemeroptera being *Pseudocloeon* sp. A, *Aprionyx peterseni* and *Lithogloea pennicillata*, though *Baetis harrisoni* and *Acentrella capensis* were also common; *Pseudagrion* sp.; Corydalidae; many types of caddis; Hydraenidae, especially in the upper parts; Helodidae; Dryopidae and Helmidae; Tipulidae, especially *Limnophila nox*; Chironomidae; the Simuliidae *Simulium medusaeformis* and *S. hessei*, the former being the more abundant but the latter limited to and therefore characteristic of the zone; Blepharoceridae, especially *Elporia barnardi*; and Leptid larvae.

ZONE IIIA

The fauna of this zone was the most varied of the whole river. Naididae and Lumbricidae appeared; Nemourini were still prominent; all Berg River families of Ephemeroptera were present: Baetidae, of which *Baetis bellus* made its appearance, Caenidae, mainly *Austrocaenis* sp., Leptophlebiidae which reached their maximum, *Aprionyx tabularis*, *Choroterpes nigrescens* and *Euthraulius elegans* being most characteristic, Ephemerellidae, of which *Lithogloea harrisoni* reached its maximum, and Heptageniidae (*Afronurus harrisoni*); Zygoptera (*Pseudagrion* spp.) continued and the Anisopteran larvae, *Aeschna minuscula* and *Paragomphus cognatus* appeared; Corydalidae declined but Trichoptera reached their maximum both in numbers of species present and families represented; Pyralidae were present; Dryopidae declined but Helmididae reached their maximum especially 8J and 6AA; Helodidae were important; Chironomidae were more important than in Zone II; Simuliidae were represented by seven species; Blepharoceridae were still important but the species present was *Elporia uniradius*; Leptid and Empid larvae were present.

ZONE IIIB

In this zone all groups decreased, particularly species typical of the upper reaches of the river, especially Nemourini, Leptophlebiidae, Ephemerellidae, Heptageniidae, most of the Trichoptera (except a few Leptoceridae, Hydropsychidae and Hydroptilidae), all Dryopidae and Helmididae, some Hydraenidae, and all Blepharoceridae and Leptidae. On the other hand Nemertini (*Prostoma* sp.) appeared in numbers as well as Naididae, Lumbricidae and Cladocera. Baetid mayflies maintained an important position, especially *Baetis harrisoni*, *B. bellus* and *Pseudocloeon vinosum*; *Acentrella capensis* fell away but *Centroptilum excisum* became common; *Baetis* sp. A, *Pseudocloeon maculosum* and *Centroptilum pulchrum* appeared; Corixidae, especially *Micronecta piccanin*, became important and *Nychia limpida* appeared; Simuliidae were represented by the maximum number of species (8), and Chironomidae were important, mainly Chironominae and Orthoclaadiinae but also Tanypodinae. *Aeschna minuscula* nymphs in the runs and *Paragomphus cognatus* in the sand were conspicuous, especially during the months December to March. Most important was the appearance of Lymnaeidae.

ZONE IV

Prostoma sp. persisted, often in large numbers in areas of slow flow, and *Ferrissia* sp. occurred all over the zone. Naididae were often common, especially *Nais* sp., and the regular appearance of *Stylaria fossularis* from Station 18 down was most characteristic. Lumbricidae and Tubificidae were found in muddy or muddy-sandy bottoms; *Simocephalus* spp. occurred in the dry months; Baetidae were an important feature, especially *Baetis bellus*, but *Pseudocloeon vinosum* was often abundant in winter and spring; *Baetis* sp. B, though never numerous, was a most characteristic species from Station 16 down; *Centroptilum excisum* was practically universal, and *Baetis* sp. A as well as *B. harrisoni* and *Pseudocloeon maculosum* occurred in stony runs where *Tricorythus discolor* was very prominent in spring, summer and autumn; *Austrocaenis* sp. was also very common all over the whole zone. *Pseudagrion* spp. and *Paragomphus cognatus* were common, especially in summer; *Micronecta* spp. were common to abundant in the drier months and *M. bleekiana* was especially prominent; Naucorids appeared from Station 16 down. Though other caddis were found, the only really prominent species was *Cheumatopsyche zuluensis* in the runs at Station 18. Chironomidae, especially Chironominae, were very abundant, except in winter, mainly in sandy bottoms where *Nilobezzia capensis* (Ceratopogonidae) formed a very characteristic part of the fauna. There were fewer species of Simuliidae (4), and *S. bovis* was the characteristic species of the zone.

ZONE V

This zone was very poor in variety, and often in number. The absence of stony runs meant the loss of the associated species, but the fauna of the marginal vegetation and muddy bottoms was generally poor. However, after fresh mud had been brought down in winter and spring, there was an outburst of small Lumbricids and Tubificids in the bottoms though their numbers fell off again in summer and autumn. *Prostoma* sp. was often fairly common, and so was *Stylaria fossularis*; estuarine Polychaeta appeared in the winter and spring as did Amphipods, especially *Chiltonia capensis*. The marginal Baetidae occurred mainly in winter and spring but *Pseudagrion* spp. were usually present in the dry months. *Micronecta* were practically always present even in winter when they were virtually absent from Zone IV; Naucorids were present. Hydrophyllid beetles were sometimes present, especially *Hydrochus gemmatulus*. Simuliidae were never encountered as current speeds must have been too low, and Chironomidae were greatly reduced in number.

I. NOTE ON THE FISH FAUNA

No special study was made on the fish, but the following are the species present and their known distribution:

INDIGENOUS FISH

CYPRINIDAE:

Barbus andrewi Brnrd. (Witvis) Zones IIIA and B and probably most of IV.

Barbus burchelli A. Smith (Rooivlerk) Zones IIIA and B.

GALAXIDAE:

Galaxias zebratus Cast. Zones II, IIIA and B and possibly much of IV.

Galaxias punctifer Cast. Zones IIIB, IV and V.

(Probably one species, see Barnard 1943.)

ANABANTIDAE:

Sandelia capensis (C. & V.) (Cape Kurper) Lower Zone II to V.

MUGILIDAE:

Mugil cephalus Linn. (Springer) Zone V and probably lower Zone IV.

The distribution of indigenous fishes is discussed by Barnard (1943).

INTRODUCED FISH (Information supplied by Mr. A. C. Harrison)

Salmo fario Linn. (Brown trout) Lower Zone II, IIIA and Upper Zone, IIIB. (Introduced 1894.)

Salmo gairdnerii irideus (Rainbow trout) Lower Zone II, IIIA and B, unconfirmed reports from IV (Station 16) may run to estuary. (Introduced 1901.)

Salvelinus fontinalis (Mitchill) (Brook trout) Recently introduced into Zone II tributary (1951), reported from IIIA.

Micropterus salmoides (Lacépède) (Large-mouth black bass) Introduced into Zone IIIB in 1930 but largely displaced by floods in 1941-2 and place taken by next species. Probably still in IIIB and IV.

Micropterus dolomieu Lacépède (Small-mouth black bass) Zones IIIA, IIIB and IV and possibly V. Introduced in 1938, seen breeding at Station 12.

<i>Micropterus punctulatus</i> (Rafinesque) (Spotted bass)	Introduced into IIIB in 1940 but do not appear to have become established.
<i>Lepomis macrochirus</i> (Rafinesque) (Blue-gill sunfish)	Zones IIIB to V, abundant. Introduced 1939.

The distribution of exotic fish is discussed in Report No. 7 of the Cape Administration's Inland Fisheries Department.

J. DISCUSSION

I. FACTORS DETERMINING THE CHARACTER OF THE RIVER

It is considered that the characteristics of the Great Berg River and of its biology are determined by the following factors:

(a) Profile

The profile is fairly simple; the bed is very steep near the mountain source, but the slope rapidly becomes less within the first ten miles, after which there is a more gradual falling-off towards the mouth as the river runs among low foothills and over a hilly plain and by-passes outliers and intrusions of resistant rocks. This profile gives rise to the main physical zones, already described.

(b) Geology of the Drainage Basin

The influence of the geology is felt not only in determining the course of the river in the relatively easily weathered rocks of the Malmesbury Series, but also in changes in the composition of the water as it passes over the Table Mountain sandstone and Malmesbury Series respectively. The T.M.S., which consists dominantly of a very pure quartzite, gives rise to waters which are notably low in dissolved salts, have a low pH due to organic acids, and run clear except at times of flood. In contrast the waters derived from the rocks of the Malmesbury Series are mineralized, buffered and turbid. As stated previously, chloride is the main anion, and magnesium is present in greater concentrations than calcium. This agrees with the findings of Bond (1946), who states that the relative proportions are nearly always the same as those of oceanic waters, viz. $\text{Cl} > \text{SO}_4 > \text{CO}_3$ and $\text{Na} > \text{Mg} > \text{Ca}$. Now NaCl is not of anthigenic origin in the Malmesbury beds, and the evidence clearly points to its derivation from a marine source. In 1928 du Toit suggested that the salts were introduced during a period when the sea covered the coastal plains. This theory is strongly supported by Bond. An alternative theory is that the introduction was effected by wind-blown spray though the distances this would have to be transported are considerable.

The mineralized run-off waters from the Malmesbury Series have a marked effect on the lower reaches of the river, but this is limited by the low rainfall over the area.

(c) Rainfall

The yearly distribution of the rainfall leads to a great seasonal variation of flow. During the dry season, the flow falls to a mere trickle and most of the river bed is

exposed. During the rainy season falls are irregular and consist of heavy falls lasting for a few hours, interspersed with days of light rain or dry weather. This results in a series of violent floods followed by rapid drops in the flow. Floods are most severe in the upper zones but have a scouring effect throughout except in the Flood Plain Zone.

(d) *Silting of the River Bed*

This process begins as the river enters farm lands in Zone IIIB and increases in Zone IV. In Zone IIIB mainly sand is deposited, but in Zone IV there is some mud, especially in backwaters. In the Flood Plain Zone deposits are mainly mud.

(e) *Seasonal Temperature Variations*

Summer temperatures in the lower zones (IIIB down) are high, often going above 30° C. Winter temperatures seldom drop below 10° C. generally, and even in the Mountain Torrent Zone temperatures below 9° C. are rare. Mountain-top temperatures must go lower as snow often lies there.

2. THE EFFECTS OF THESE FACTORS ON THE FLORA

The Mountain Torrent Zone and the Foot-hill Stony Run Zone are similar to comparable zones in European rivers in that the only bed vegetation is that which can attach itself to permanent surfaces. The place of the European *Fontinalis antipyretica* is taken by two plants. Firstly, the moss *Wardia hygrometrica* is found in the cliff waterfalls and the upper part of the Mountain Torrent, and secondly, *Scirpus digitatus* from the cliff waterfalls to the Upper Stony Run Zone. The lower distribution limits of both of these are probably set by rising summer maximum temperatures; as suitable substrates continue well below the points at which they disappear.

The presence of *S. digitatus* at all in the upper reaches is almost certainly related to the low pH of the water. This species and other aquatic or semi-aquatic species of *Scirpus*, such as *S. prolifer* and *S. fluitans*, seem to prefer distinctly acid water. The rising pH values and increasing silt load in Zone IIIB may be other factors setting the lower limit of *S. digitatus*.

In the regions of the river with extensive soft bottoms, there is almost a complete lack of phanerogamic and charophytic vegetation in the river-bed. The factors which are probably mainly responsible for this are:

- (a) The desiccation of most of the river-bed during the dry season.
- (b) The scouring floods during the wet season.
- (c) The deposition of fine silt on all surfaces in the lower parts of the river, especially after floods.

For most of the river, the scouring floods are probably most important in preventing colonization, but desiccation was seen to destroy the few growths that were able to start in quieter backwaters. This happened to some *Nitella mucronata* at Hermon. Parts of the bed still submerged in summer were unsuitable for plant growth being mainly composed of loose, coarse sand.

Erichsen Jones (1949) reports violent flooding in the River Reidol in Wales, but there some aquatic vegetation was able to colonize the lower reaches. Floods may not have been as violent as those in the Great Berg, but the obvious difference was that the river-bed was not ever subject to severe desiccation.

In the Flood Plain Zone and in the 'canal' section near Gouda (Station 14), deposition of fine silt and water turbidity probably prevented the growth of aquatic vegetation.

The banks of the river are protected for most of its length by a fringe of marginal vegetation, mainly the robust *Prionium serratum*, mixed lower down with the small willow, *Salix capensis*. Without these erosion might well be catastrophic, as has been seen during exceptional floods when this protective fringe has been broken through in places.

The Great Berg River is remarkably poor in algal flora. Even during the dry season practically no filamentous algae are to be found in the runs, riffles and backwaters. Notable exceptions were the patches of *Spirogyra* sp. in the Mountain Torrent Zone and at Wellington, and *Batrachospermum* sp. in running water from Stations 1 to 9. This lack was to be expected in the upper zones (II and IIIA) where nitrates and phosphates were very low and even sulphates dropped below the critical value of 0.5 p.p.m. suggested by Beauchamp (1953). Even lower down, however, little growth appeared even in the Paarl-Wellington region where pollution occurred. Reasons for this were not apparent from this survey.

3. THE EFFECT OF THESE FACTORS ON THE FAUNA

As in the case of the flora, the different factors interact and it is not easy to sort out their effects.

(a) *The Succession of Communities*

The succession of communities from zone to zone has been described. Most marked changes were observed in the lower Foot-hill Stone Run Zone (IIIB) where communities characteristic of mountain streams and rivers disappeared. This falling away was obviously not due to changing profile as current speeds and substratum type did not change appreciably until well below this region. The following factors would appear to be important in the disappearance of these upper river communities:

- (1) Rising summer temperatures downstream, especially summer maxima.
- (2) Increasing silt loads during flood periods and the deposition of silt after floods.

Some species are dependent on *S. digitatus*, but its disappearance is also linked to the above factors.

Upper region species are replaced by a smaller number of species which can withstand higher summer temperatures and silting. Some of these, on the other hand, are limited to the lower regions by their food requirements. Obvious examples are *Tricorythus discolor* and *Pseudocloeon maculosum* with their brush-like mouth parts, and *Cheumatopsyche zuluensis* with its filtering nets. These abounded at times at Piketberg and seemed to prefer distinctly muddy water with its associated microplankton.

(b) *Seasonal Changes*

These are brought about by:

- (1) The annual cycle of wet-season floods and dry-season quiet conditions.
- (2) Seasonal differences in turbidity and silt load, especially in the lower regions.
- (3) Rising summer temperatures, especially maxima.

The winter floods seem to have surprisingly little effect on the fauna of the stony runs and stickles of the upper zones. Even after severe floods, when the 'molar' action of moving stones must have been extensive, numbers were not greatly reduced (see section (g)). This was in contrast to conditions reported by Erichsen Jones (1949) from the Reidol where silt-laden flood-waters drastically reduced the fauna. Conditions similar to these were found in the small runs at Picketberg where there were few animals during flood periods. Here large quantities of moving sand would have helped to dislodge stone-clinging fauna.

Effects of flooding were far more serious on the fauna of quieter biotopes. During the dry season extensive communities developed in and on soft bottoms and much zooplankton was to be found, especially in the quieter backwaters of lower Zone IIIB and Zone IV. *Simocephalus* spp., true lotic forms, multiplied in the marginal vegetation, and Corixidae appeared in large numbers in quiet shallows and margins. The floods swept practically all these away.

The factors of turbidity and silt load appeared to be more important in their effects on the zonation of communities rather than on seasonal changes. Their effects were so closely linked to those of flooding that they were not easily separated.

The effects of summer temperatures on the zonation of communities have been discussed. Some upper region species are found lower downstream in the winter when the lower temperatures probably assist their survival there (e.g. *Pseudocloeon* sp. A.). However, the effect of temperature changes alone on seasonal variation seems to be somewhat limited as there is little downstream migration in winter. Winter silt loads in the lower zones are probably an effective barrier to this.

An example of the combined action of the above factors is seen in the distribution of the Baetidae of marginal vegetation. The two commonest species were *Baetis bellus* and *Pseudocloeon vinosum*. *Ps. vinosum* was found wherever the vegetation was washed clean by the current and it was not adversely affected by the heavy winter silt loads in Zones IV and V. However, in summer it was seldom found in these lower zones except on pieces of vegetation which were actually trailing in the stream, whereas in Zones II and IIIA it occurred generally even in places where the water movements were slight. It was observed, during summer and autumn, that most vegetation from Station 12 down was coated with a layer of silt matted with diatoms and other algae. It appears that *Ps. vinosum* cannot thrive on such contaminated surfaces and is therefore limited to clean trailing vegetation in the lower zones. It is not known what part lower maximum temperatures play in its increased tolerance to lower current speeds in the upper zones.

Baetis bellus also demands water movements in the vegetation, hence its low incidence at Station 14 and in Zone V. However, as it can tolerate contaminated

Not enough is known of the zonation of the indigenous fishes of the Great Berg to attempt to relate Zone IV to the European Grayling and Bream Zones.

5. GREAT BERG RIVER ZONATION AND OTHER SOUTH AFRICAN RIVERS

Most South African rivers are geologically young and have the same physical zones as the Great Berg. However, most are not as simple as they cut through more than one geological formation. This gives them a step-like profile and leads to a repetition of stony run and soft bottom zones.

Sommani (1953) has pointed out that similar step-like profiles of some Italian rivers, notably the Adige, lead to a repetition of trout and grayling zones. These are determined by the slope of the watercourse and are altogether independent of the altitude. He does point out, however, that in some cases the slope factor may become subordinate to other factors, such as flow and temperature, in determining the fish fauna of a particular stretch of the river.

In certain South African rivers, where zones are repeated several times, it is unlikely that communities will also be repeated. This was found to be the case in the small repetition of the stony run zone at Piketberg (Station 18) where the fauna was markedly different from that at Wellington. Factors which would act in addition to the slope factor would be maximum summer temperatures, minimum winter temperatures, silt load and sedimentation rate, and substratum differences. These latter may be due to changes in the geological nature of the stones in the river-bed, changes in the composition of the soft bottoms, or to different types of stream-bed and marginal vegetation. Another factor would be the increase in nutrient salts downstream, coming from various sources, which would induce the growth of plankton and attached algae with concomitant changes in the fauna.

At Piketberg all these factors were of importance, except the temperature range which was much the same as in Zone IIIB. The substratum change was from rounded sandstone stones to flat pieces of shale.

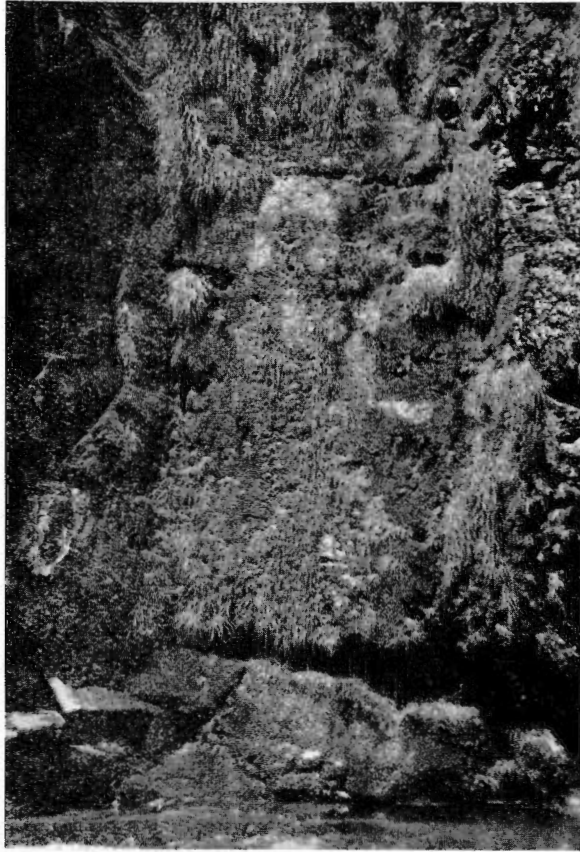
In other South African rivers the same factors also operate, but in some, changes in the temperature range downstream are much more marked. Eastward-flowing rivers in Natal and in the Transvaal, for instance, start in high mountain ranges and then flow through elevated valleys, well inland, where winter temperatures are low and frost is common. They then drop into subtropical coastal regions where winter temperatures remain relatively high and summer temperatures are very high. Subtropical species are to be expected here. Preliminary collecting in the Lowveld of the Transvaal has indicated that this is the case. In this connection the results of the survey of the Tugela River, in Natal, are awaited with interest. This is being conducted by Mr. W. D. Oliff, Pietermaritzburg.

The streams of the Highveld region of the Transvaal and Orange-Free State have slow-flowing headstreams and no mountain zones. The characteristic mountain zone fauna is entirely absent and lower zone communities appear very early. A survey of one such stream system is being conducted by Mr. B. R. Allanson of the Transvaal Nature Conservation Department.

REFERENCES

- Allen, K. Radway. 1951. 'The Horokiwi Stream.' *New Zealand Marine Department Fisheries Bull.*, No. 10.
- Barnard, K. H. 1927. 'A study of the freshwater Isopodan and Amphipodan crustacea of South Africa.' *Trans. Roy. Soc. S.A.*, xiv, Part 2.
- 1931. 'The Cape Alder-flies (Neuroptera, Megaloptera).' *Trans. Roy. Soc. S.A.*, xix, Part 2.
- 1932. 'South African May-flies (Ephemeroptera).' *Trans. Roy. Soc. S.A.*, xx, Part 3.
- 1934A. 'South African Caddis-flies (Trichoptera).' *Trans. Roy. Soc. S.A.*, xxi, Part 4.
- 1934B. 'South African Stone-flies (Perlaria) with descriptions of new species.' *Ann. S.A. Mus.*, xxx, Part 4 (17).
- 1937. 'Notes on Dragon-flies (Odonata) of the S.W. Cape, with description of the nymphs and of new species.' *Ann. S.A. Mus.*, xxxii, Part 3 (12).
- 1940. 'Additional records and descriptions of new species of South African Alder-flies (Megaloptera), May-flies (Ephemeroptera), Caddis-flies (Trichoptera), Stone-flies (Perlaria), and Dragon-flies (Odonata).' *Ann. S.A. Mus.*, xxxii, Part 6.
- 1943. 'Revision of the indigenous freshwater fishes of the S.W. Cape Region.' *Ann. S.A. Mus.*, xxxvi, Part 2.
- 1947. 'The Blepharoceridae (Diptera) of the S.W. Cape.' *Journ. Ent. Soc. S.A.*, x, Part 2.
- Beauchamp, R. S. A. 1953. 'Sulphates in African Inland Waters.' *Nature* 171, May 2, 1953.
- Berg, K. 1943. 'Physiographical Studies on the River Susaa.' *Folio Limnologica Scandinavica* (1).
- 1948. 'Biological Studies on the River Susaa.' *Folio Limnologica Scandinavica* (4).
- Bond, G. W. 1946. 'A Geochemical Survey of the Underground Water Supplies of the Union of South Africa, with particular reference to their utilization in power production and industry.' Memoir No. 41 Geol. Surv. S.A.
- Carpenter, K. E. 1928. *Life in inland water*. London.
- Crass, R. S. 1947. 'The May-flies (Ephemeroptera) of Natal and the Eastern Cape.' *Ann. Nat. Mus.*, xi, Part 1.
- Day, J. H., Millard, N. A. H., and Harrison, A. D. 1952. 'The Ecology of South African Estuaries. Part III Knysna: A clear, open Estuary.' *Trans. Roy. Soc. S.A.*, xxxiii, Part 3.
- Du Toit, A. L. 1928. 'Borehole Water Supplies in the Union of South Africa.' *Min. Proc. S. Afr. Soc. Civ. Engrs.*, 74-133.
- *The Geology of South Africa*.
- Harrison, A. C. 1934. 'A preliminary report on the Groot Drakenstein trout streams.' *Cape Piscatorial Society Circular* No. 21.
- Huet, M. 1946. 'Note préliminaire sur les relations entre la pente et les populations piscicoles des eaux courantes.' *Biol. Jaarb.* (13), 232-43, Dodonaea.
- 1949. 'Aperçu des relations entre la pente et les populations piscicoles des eaux courantes.' *Rev. Suisse d'Hydrologie*, 3-4, 332-51.
- Hutchinson, G. Evelyn. 1929. 'A revision of the Notonectidae and Corixidae of South Africa.' *Ann. S.A. Mus.*, xxv, Part 3 (11).
- Inland Fisheries Department. Provincial Administration of the Cape of Good Hope, Report No. 7 (1950).
- Jones, J. R. Erichsen. 1940. 'A study of the zinc-polluted river Ystwyth in North Cardiganshire, Wales.' *Ann. Appl. Biol.*, 27, 368-78.
- 1941. 'The fauna of the River Dovey, West Wales.' *J. Anim. Ecol.*, 10, 12-24.
- 1943. 'The fauna of the River Teifi, West Wales.' *J. Anim. Ecol.*, 12, 115-23.
- 1948. 'The fauna of four streams in the "Black Mountain" district of South Wales.' *J. Anim. Ecol.*, 17, 51-65.
- 1949. 'An ecological study of the River Reidol, North Cardiganshire, Wales.' *J. Anim. Ecol.*, 18, 67-87.
- 1950. 'A further ecological survey of the River Reidol: the food of the common insects of the main stream.' *J. Anim. Ecol.*, 19 (2).
- 1951. 'An ecological study of the River Towy.' *J. Anim. Ecol.*, 20 (1).
- Kimmins, D. E. 1956. 'New and little-known species of the Leptocerinae (Trichoptera) from the African mainland.' *Trans. R. ent. Soc. Lond.*, 108 (4), 117-46.
- Macan, T. T., and Worthington, E. B. 1951. *Life in Lakes and Rivers*, London.

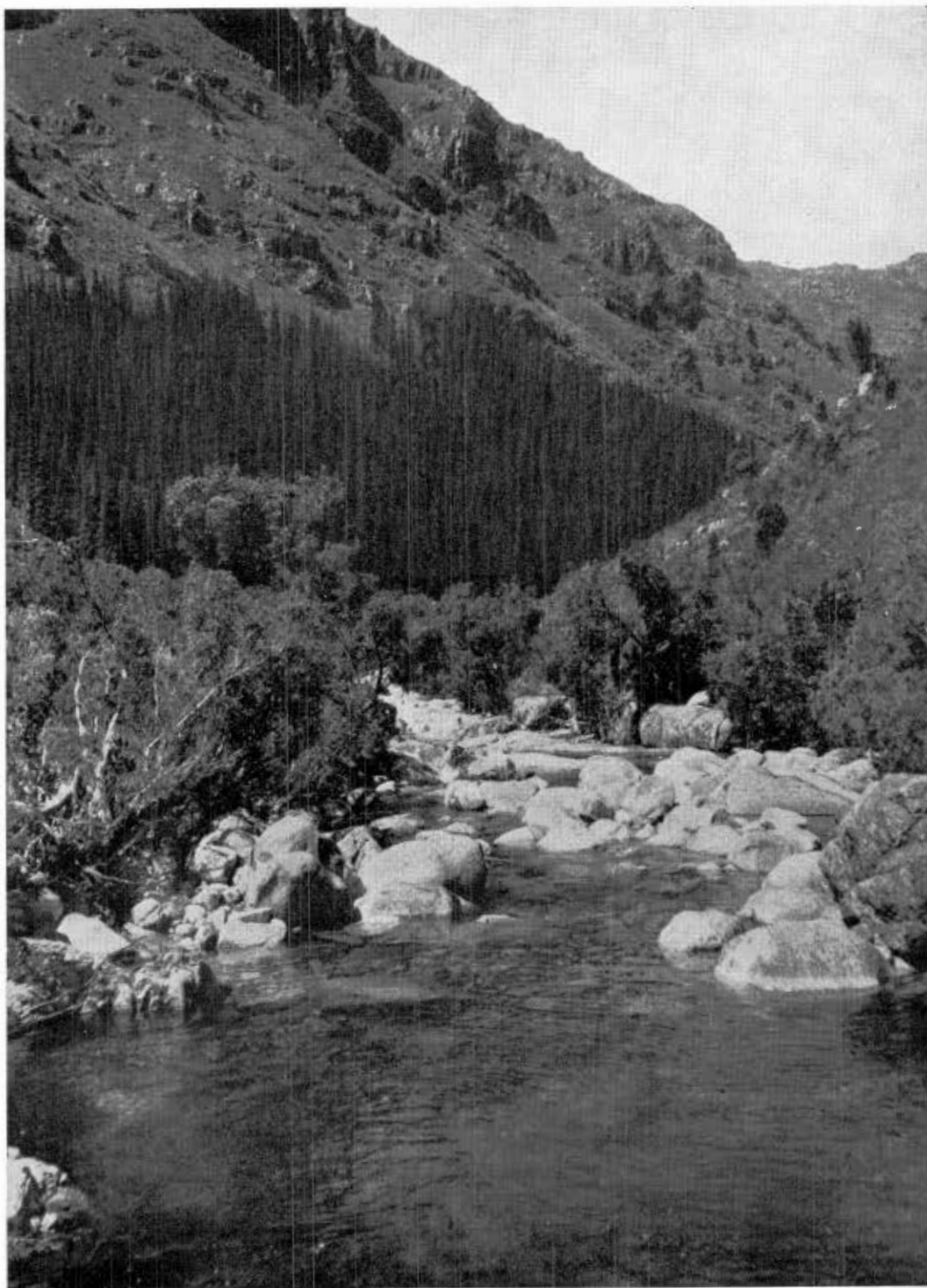
- Macfadyen, A. 1945. 'The invertebrate fauna of Jan Mayen Island (East Greenland).' *J. Anim. Ecol.*, 23 (2), 261-97.
- Millard, N. A. H., and Scott, K. M. F. 1954. 'The ecology of South African Estuaries, Part IV, Milnerton Estuary and the Diep River, Cape.' *Trans. Roy. Soc. S.A.*, xxxiv (2).
- Nielsen, A. 1950. 'The Torrential invertebrate fauna.' *Oikos*, II (2), 176-96.
- Sars, G. O. 1916. 'The Fresh-water Entomostraca of the Cape Province (Union of South Africa). Part 1. Cladocera.' *Ann. S.A. Mus.*, xv, Part 4 (4).
- 1924. 'The fresh-water Entomostraca of the Cape Province (Union of South Africa). Part 2. Ostracoda.' *Ann. S.A. Mus.*, xx, Part 2 (2).
- 1927. 'The fresh-water Entomostraca of the Cape Province (Union of South Africa). Part 3. Copepoda.' *Ann. S.A. Mus.*, xxv, Part 1 (3).
- Scott, K. M. F., Harrison, A. D., and Macnac, W. 1952. 'The Ecology of South African Estuaries. Part II. The Klein River Estuary, Hermanus, Cape.' *Trans. Roy. Soc. S.A.*, xxxiii (3).
- Sommani, E. 1953. 'Il concetto di "zona ittica" e il suo reale significato ecologico.' *Boll. Pesca, Piscic. Idrobiol.*, 7 (1), 61-71.
- Tansley, A. G. 1923. *Practical Plant Ecology*, London.
- Wood, H. G. 1952. 'The Crane-flies of the South-West Cape (Diptera, Tipuloidea). *Ann. S.A. Mus.*, xxxix.



A. A Cliff Waterfall, portion shown is about 18 feet high. As it was summer there was a mere trickle of water. *Pentaschistis capensis* can be seen at the sides and at top left, and *Scirpus digitatus* in the centre, especially towards the bottom. Dark patches of the moss, *Wardia hygrometrica*, are also visible.



B. 'Sponge' in Sneegat showing swamp vegetation.



Mountain Torrent Zone about two miles above Station 1. Note the bed strewn with boulders and rocks, with occasional pools.



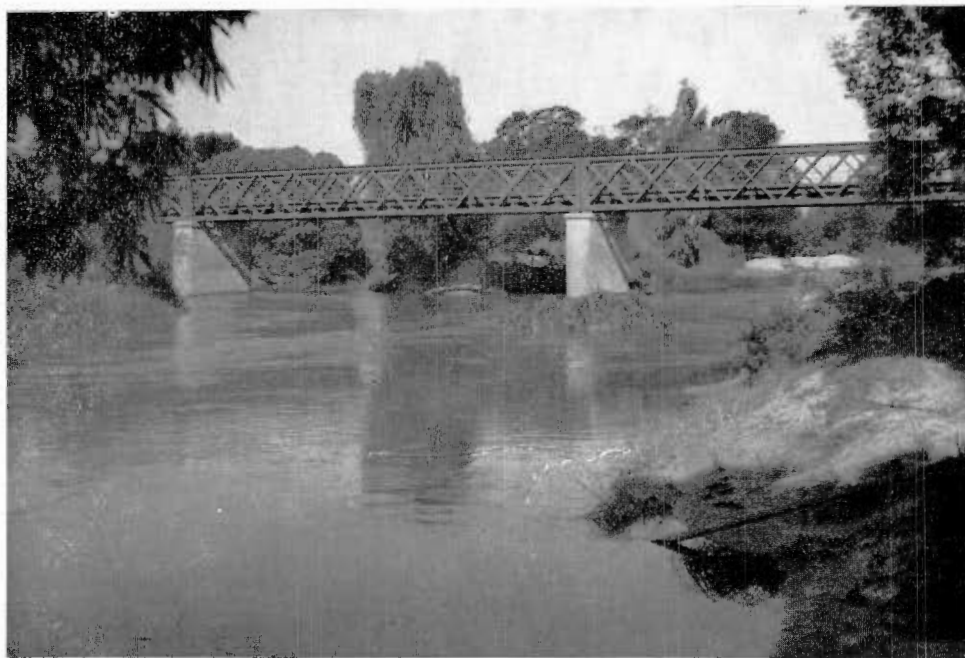
A. A stickee at Station 3. Note patches of *Prionium serratum* (palmiet) along the bank and in the bed, also protruding *Scirpus digitatus* in the right foreground. [PHOTO: R. PILCHER]



B. Upper Foot-hill Stony Run Zone, Station 5. The river was running at a fairly high spring level. Note the large area of stony bed exposed and the large patches of *Prionium serratum* growing much taller than at Station 3 (above).



A. River at Wellington (Station 12) at low summer level. The stony channel coming from the right is quite dry; there was a slow flow in the channel between the trees left of centre. Note large patch of *Prionium serratum* right of centre. Grass growing into the water in the foreground is *Paspalum vaginatum*.



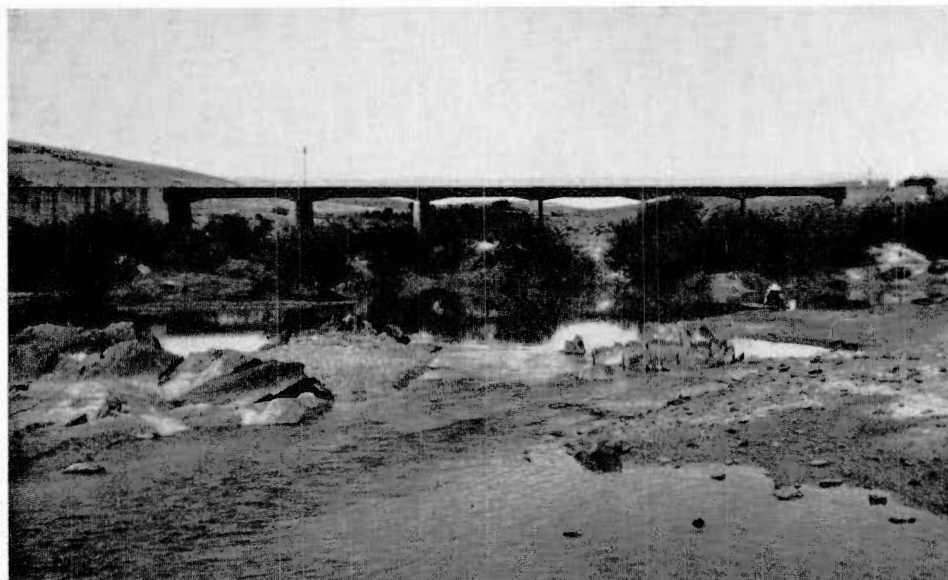
B. River at Wellington (Station 12) during a receding winter flood. Note high water mark on right bank above pipe. The large patch of *P. serratum* in the bed was completely submerged at the height of the flood.



A. Foot-hill Soft Bottom Zone. Station 16, summer level. Note sandy bed, mostly exposed, and water flowing in a narrow, shallow channel. A secondary channel in the centre, foreground, has dried up.



B. Station 16, receding winter flood level. Bank plants provide a temporary harbourage for marginal animals.



A. Stony stickles near Piketberg (Station 18), low summer level. The bush on the small islands is mainly *Salix capensis*.



B. The river near Piketberg (Station 18) at high winter level. Patches of *Prionium serratum* and an occasional *Salix capensis* can be seen growing in the stream bed.



A. The canal-like stretch at Gouda (Station 14) in spring. The marginal vegetation is mainly *Prionium serratum* and *Salix capensis*, but there are patches of *Polygonum* spp. A sandy beach can be seen on the left.



B. Flood Plain Zone, farm Kersefontein (Station 21). Beyond the muddy beach on the left is a large patch of *Cyperus textilis* and *Polygonum salicifolium*. The far bank is clothed mainly with *Phragmites communis*, *Cyperus textilis*, *Prionium serratum* and *Cliffortia strobilifera*.

HYDROBIOLOGICAL STUDIES ON THE GREAT BERG RIVER, WESTERN CAPE PROVINCE

PART 2

Quantitative studies on sandy bottoms, notes on tributaries and further information on the fauna, arranged systematically

BY A. D. HARRISON*

National Chemical Research Laboratory

SUMMARY

This part consists of three sections. The first deals with quantitative studies of the fauna of sandy bottoms sampled at two points on the river; a Birge-Ekman grab was used and samples were sifted through No. 3 grit gauze. The second section deals with the bottom fauna of three tributaries and discusses possible reasons for differences between these faunas and that of the main river. The third section comprises biological notes on most of the species encountered during the survey; these are arranged systematically.

CONTENTS

	PAGE		PAGE
INTRODUCTION	227	2. Fauna of a Temporary Stream: the Kuils River	239
A. QUANTITATIVE STUDIES ON THE FAUNA OF SANDY BOTTOMS	228	3. The Sout River, Hopefield, a Strongly Saline Temporary Stream	242
1. Sand Fauna at Wellington	229	C. NOTES ON THE FAUNA OF THE GREAT BERG RIVER (arranged in sys- tematic order)	244
2. Sand Fauna at Station 18, near Piquetberg	232	REFERENCES	275
3. General Considerations	236		
B. NOTES ON TRIBUTARIES OF THE GREAT BERG RIVER.	236		
1. A Shaded Forest Stream at Assegailbos (Station 2)	236		

INTRODUCTION

Of necessity many details of the biology of individual species had to be omitted from Part 1 of this series, not because they were thought to be unimportant but because they would have obscured the main issues. It was realized, however, that these details should be recorded if the work on the Great Berg River was to form a proper foundation for future hydrobiological studies in the Western Cape Province and in other parts of South Africa. These details are given in Section C of this part.

During the course of the main survey some attention was given to the tributaries of the Great Berg. A number of these, such as the Wemmer River, were very similar

* The work was carried out in the Zoology Department, University of Cape Town.

to the upper reaches of the Great Berg itself and so the results of the samplings from them have not been discussed. Some, however, were very different from the main stream in any of its reaches, and these are described in Section B with emphasis on the effects of the different environmental conditions on the fauna.

For most of its length, from Paarl to the head of the estuary, the bed of the Great Berg largely consists of shallow pools and 'flats' floored with sand. During the wet season these sandy bottoms are unstable as periodic floods scour them out, but during the dry season they remain undisturbed and a fauna of burrowing and surface-dwelling animals develops. During the latter part of this survey special attention was given to this fauna and quantitative samples were taken. As these samples were sifted through much finer bolting silk than that used for the main survey, results were not comparable and were not discussed in Part 1.

A. QUANTITATIVE STUDIES OF THE FAUNA OF SANDY BOTTOMS

The object of these studies was to gather information on the seasonal development of the fauna of the sandy bottoms described above and in Part 1. Sampling commenced when conditions began to be stable, as the rainy season slackened, and was continued until most of the fauna was swept away by the first serious floods of the next rainy season.

Methods. Samples were taken with a Birge-Ekman grab with a handle (Lenz modification). This had an opening of 15 cm. square and the box was 22 cm. high. Three grab samples were taken at each sampling site and the contents emptied into a white, enamel bucket on the spot. The sand was stirred with water which was decanted through a net of No. 3 silk grit gauze (58 meshes to the inch). As much sand as possible was left behind in the bucket. Washing was repeated until careful examination showed that no more animals were being extracted from the sand. Samples were bottled in weak formalin and the fauna was identified and counted in the laboratory under a dissecting microscope.

Shallow pools, quieter parts of flats and small backwaters were sampled, most of them from 1 to 2 feet deep (30 to 61 cm.) The grab bit into the bottom to a depth of 4 to 5 cm. but occasionally deeper when the bottom was unusually soft.

The results of these studies should be compared with those of hand-net samplings from sandy bottoms recorded in Part 1, page 192. These latter included a number of active swimmers which live on the bottom, such as *Micronecta* spp. and *Centroptilum excisum*, and the active, burrowing nymphs of *Paragomphus cognatus*. All these, and to some extent even *Simocephalus* spp., were seen to swim away at the approach of the grab. Grab samples, therefore, can give no idea of their number. Smaller, planktonic crustacea, such as *Macrothrix* spp. and *Bosmina* spp., were not able to escape. It was also noted that, during the day, small Cladocera and Copepoda either rested on the bottom or swam within a few centimetres of it. The majority of these, therefore, would have been caught in the grab.

The net used was fine enough to trap the smallest entomostraca as well as Naididae, Chironomidae and Ceratopogonidae.

Samples were taken at two stations: 1. Wellington, Station 12, which lies towards the bottom of the Foot-hill, Stony Run Zone, where extensive sandy bottoms begin to appear (Zone IIIB). 2. Station 18, near Piketberg, on the Foot-hill, Soft Bottom Zone (Zone IV). The physical and chemical conditions of the water are described in Part 1.

1. SAND FAUNA AT WELLINGTON. (Figure 4, Tables 31, 32 and 33.)

The bottom here was mainly of fine sand with a little woody vegetable detritus. During January and February strands of filamentous algae, *Spirogyra*, etc., were noticeable and there were numbers of diatoms.

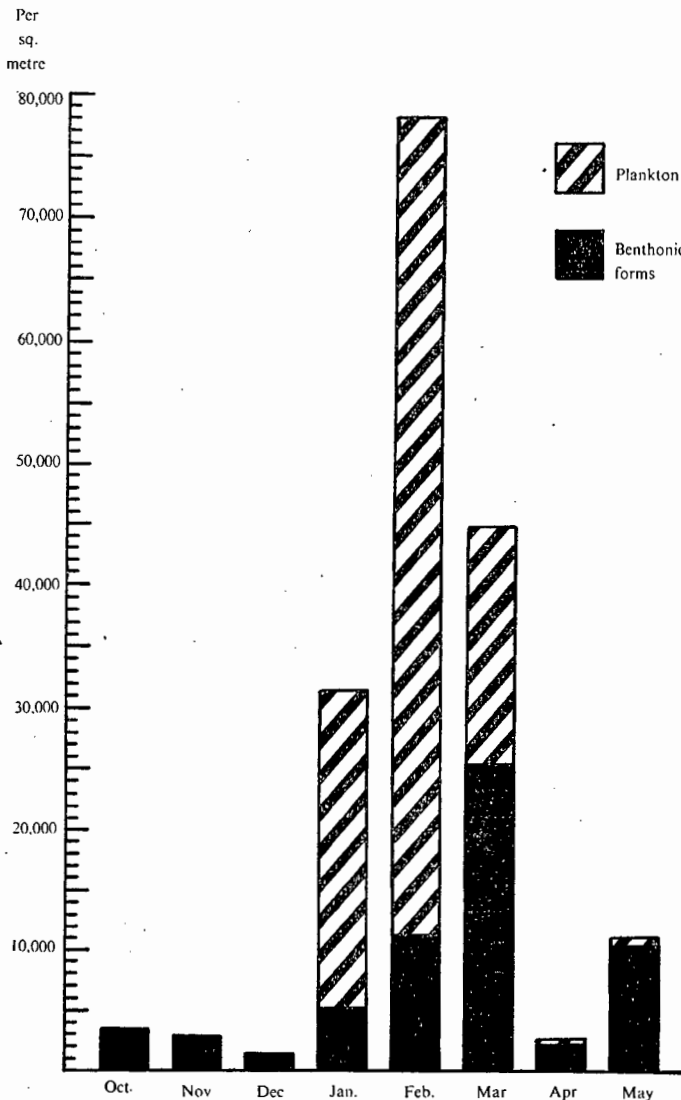


FIG. 4. Density of fauna in and on sandy bottoms at Station 12.

TABLE 31. BENTHONIC ANIMALS AT WELLINGTON (STATION 12)

	October		November		December		January		February		March		April		May	
	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%	/sq. cm.	%
Nematoda	—	—	—	—	—	—	276	5.8	—	—	592	2.3	30	1.3	445	4.4
<i>Nais</i> sp.	—	—	375	13.5	—	—	—	—	—	—	4,692	18.4	310	13.5	133	1.3
<i>Slavina appendiculata</i>	1,924	56.0	88	3.1	30	1.9	15	0.3	—	—	15	0.06	—	—	—	—
<i>Tubifex</i> sp.	—	—	266	9.5	—	—	—	—	15	0.1	—	—	—	—	—	—
<i>Lumbriculus</i> sp.	—	—	777	27.8	222	14.2	207	4.0	103	0.9	370	1.5	—	—	2,002	19.7
Ostracoda	—	—	155	5.6	—	—	2,116	41.3	1,480	13.2	3,937	15.5	47	2.0	90	0.9
(<i>Stenocypris</i> sp.)	—	—	—	—	—	—	mostly	—	(977)	—	mostly	—	(47)	—	(90)	—
(Others)	—	—	—	—	—	—	—	—	(503)	—	—	—	—	—	—	—
<i>Centropitulum excisum</i>	59	1.7	44	1.6	45	2.8	—	—	—	—	15	0.1	44	1.9	45	0.4
<i>Austrocaenis</i> sp.	—	—	—	—	15	0.9	30	0.6	59	0.5	89	0.3	666	29.0	1,112	10.9
<i>Paragomphus cognatus</i>	—	—	—	—	30	1.9	163	3.2	15	0.1	30	0.1	44	1.9	90	0.9
<i>Trilhemis</i> spp.	—	—	—	—	45	2.9	45	0.9	15	0.1	15	0.6	—	—	—	—
Chironomidae	1,450	42.5	755	27.1	977	62.6	1,672	32.6	8,909	79.1	15,287	60.0	785	34.2	5,028	49.6
<i>Nilobezzia capensis</i>	—	—	22	0.8	—	—	148	2.9	444	3.8	88	0.3	—	—	44	0.4
TOTAL	3,433	—	2,788	—	1,560	—	5,126	—	11,175	—	25,471	—	2,294	—	10,146	—

TABLE 32. PLANKTONIC ANIMALS AT WELLINGTON (STATION 12)

	October		November		December		January		February		March		April		May	
	/sq. m.	%	/sq. m.	%	/sq. m.	%	/sq. m.	%	/sq. m.	%	/sq. m.	%	/sq. m.	%	/sq. m.	%
<i>Moina</i> sp.	—	—	—	—	—	—	—	—	1,820	2.7	74	0.4	—	—	—	—
<i>Macrothrix</i> sp.	—	—	—	—	—	—	19,684	74.6	25,841	38.6	7,844	40.4	15	4.6	—	—
<i>Bosmina</i> sp.	—	—	—	—	—	—	—	—	15,954	23.8	3,774	19.4	—	—	—	—
<i>Leydigia</i> sp.	—	—	—	—	—	—	—	—	1,894	2.8	1,657	8.5	74	22.7	45	5.1
<i>Alona</i> sp.	—	—	22	100	—	—	770	2.9	—	—	—	—	—	—	—	—
<i>Chydorus</i> sp.	—	—	—	—	—	—	—	—	5,698	8.5	—	—	—	—	—	—
<i>Cyclops</i> sp.	—	—	—	—	—	—	5,920	22.4	15,658	23.4	6,068	31.3	237	72.6	846	95.0
TOTAL	—	—	22	—	—	—	26,374	—	66,865	—	19,417	—	326	—	891	—

TABLE 33. CHIRONOMIDAE IN SANDY BOTTOMS AT STATION 12

	1952 October		November		December		1953 January		February		March		April		May	
	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%
Chironomini ^a	92	6.3	4	0.5	224	22.9	220	13.1	7,944	89.1	9,900	64.8	58	7.3	752	15.0
Tanytarsini (mixed)	13 ^b	0.9	—	—	86 ^c	8.8	60 ^d	3.5	—	—	5,225 ^d	34.1	638 ^b	81.3	4,136 ^d	82.2
Tanytarsini, <i>Zavrelia</i> -type	13	0.9	18	2.4	—	—	60	3.5	662	7.9	—	—	—	—	—	—
<i>Procladius</i>	—	—	593	78.5	294	30.0	1,261	75.4	296	3.3	162	1.0	—	—	66	1.3
<i>Pentaneura</i>	—	—	140	18.5	392	38.0	70	4.1	—	—	—	—	89	1.1	66	1.3
<i>Corynoneurinae</i>	1,352	93.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—

% = percentage composition of the Chironomidae.

^a Mainly the *Cryptochironomus-Endochironomus*-type, with a few *Chironomus* s. str. in December and February, and a number of unplaceable, 8 mm. long larvae, with 6 jointed antennae and alternatively placed Lauterborn organs, in February and March.

^b '*Paratanytarsus*' type.

^c Mostly '*Paratanytarsus*' but a few '*Neozavrelia*' type.

^d Mixed '*Paratanytarsus*' and the same '*Neozavrelia*' type larvae.

All the above determined from Hennig, 1950. The '*Zavrelia*' type larvae, very long, tubular, pre-anal, papillae.

Sampling began in October 1952, when the worst floods of the rainy season were over, and continued until May 1953, after flooding had recommenced (see Part I, Section D, 1).

Figure 4 shows the number of benthonic animals as well as the summer outburst of small, crustacean plankton. Tables 31 and 32 give the numbers of benthonic and planktonic species as well as the percentage composition of these two components of the fauna. Table 33 gives details of the Chironomidae.

In October benthonic animals were mainly Chironomidae (mainly *Corynoneura* sp.) and surface-dwelling *Slavina appendiculata* (Naididae). In November *S. appendiculata* fell off as well as the Chironomidae to a lesser extent. Large numbers of *Lumbriculus* sp. appeared and *Nais* sp. and *Tubifex* sp. made fleeting appearances. In December the fauna was mostly *Lumbriculus* and Chironomidae.

During January there was a sudden outburst of small crustacean plankton and the numbers of these increased to a maximum in February (Table 32). At the same time numbers of benthonic animals were also rising and reached their maximum in March. Table 31 shows that they were mainly Chironomidae though the numbers of Ostracoda rose steadily and there was an outburst of *Nais* sp.

The first rains in April (Table 1) sent down quite a heavy flood which washed out both plankton and bottom forms (fig. 4). By May there was some recovery even though further rains had intervened, but very little plankton reappeared. *Austrocaenis* sp. rose steadily in numbers and seemed to be little affected by these first floods.

It is interesting to note how quickly *Lumbriculus* sp. and Chironomidae were able to re-establish themselves after the April and May floods. There were two short flood periods in April, the second, on 20th, produced the maximum rate of flow recordable at the weir, 17,615 cusecs. The samples were taken on April 29. There was no further heavy rain until the period, May 20 to 22, and this also produced the maximum recordable rate of flow, but did not appear to have been so heavy as the April rain. Samples were taken on May 24. Unfortunately it was not possible to continue the sampling programme after the really heavy floods that occurred at the end of May.

An indication of rainy season conditions can be gained from a sample taken after severe floods in May 1951. This was washed through a 23 mesh to the inch net which would have retained many Chironomidae and *Austrocaenis* sp. were they present. However, there were none of these in the sample but only *Lumbriculus* sp. (277/sq. met.).

2. SAND FAUNA AT STATION 18, NEAR PIKETBERG. (Figure 5, Tables 34, 35 and 36.)

River bottoms here were mainly of fine sand mixed with a very small amount of mud, but with much fine, woody detritus. During January and February there were thin surface growths of diatoms and filamentous algae.

The first samples were taken on September 25, 1952, thirteen days after the last severe flood of winter, and the final samples of the monthly series in April 1953.

One further batch was taken on August 28, 1953, just after the rainy season had passed its maximum.

Figure 5 shows the total numbers of benthonic and planktonic animals. Table 34 gives the numbers of benthonic species, Table 35 the numbers of planktonic species and Table 36 the details of the Chironomidae.

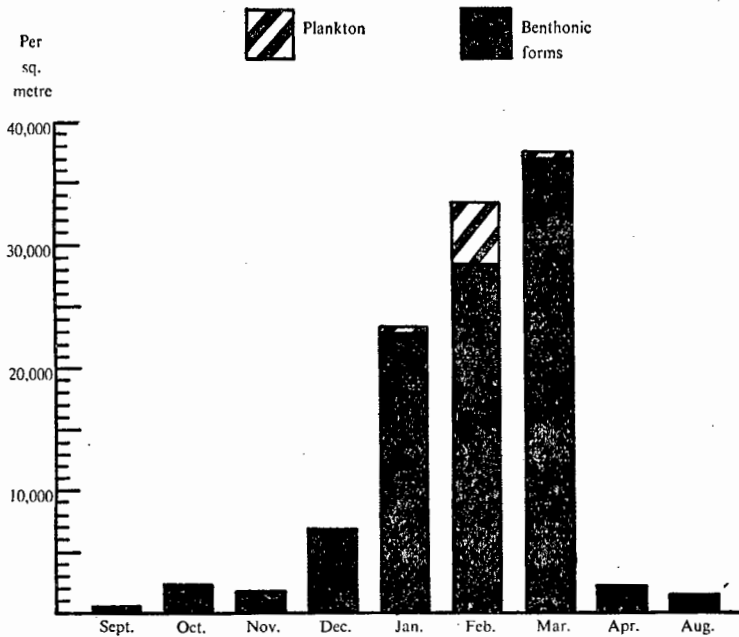


FIG. 5. Density of fauna in and on sandy bottoms at Station 18.

There were very few benthonic animals in September and these were mainly Chironomidae. A further moderate flood on October 11 did not prevent an increase in the fauna, sampled on October 29, which was mainly due to the appearance of *Lumbriculus* sp. A rapid increase in total numbers began in December and continued until March. April rains greatly reduced the fauna and the August sample indicated that this low level continued throughout the rainy season.

Benthonic fauna mainly consisted of *Lumbriculus* sp. and Chironomidae with large numbers of *Cyprilla* sp. during January and February. Naididae were only abundant in March. *Lumbriculus* sp. did not seem to be able to stand rainy season conditions. *Nilobezzia capensis* was commoner in this part of the river than at Wellington.

Small planktonic crustacea appeared in January and reached their maximum in February. Numbers were fewer and the composition was different from that at Wellington which could have been at least partly due to the slight organic pollution at Wellington.

TABLE 34. BENTHONIC ANIMALS FROM SANDY BOTTOMS AT PIKETBERG (STATION 18)

	September /sq. m. %	October /sq. m. %	November /sq. m. %	December /sq. m. %	January /sq. m. %	February /sq. m. %	March /sq. m. %	April /sq. m. %	August /sq. m. %
Nematoda . . .		30 1.4	15 0.8			222 0.8	30 0.1		22 1.4
<i>Nais</i> sp. . . .								15 0.7	110 7.0
Small Naididae . . .							14,726 7.0		
<i>Lumbriculus</i> sp. . .		1,154 52.2	888 46.9	444 6.4	1,815 7.9	370 1.3	2,664 12.7	947 45.4	
<i>Cypridopsis</i> sp. . .			222 11.7	30 0.4	110 0.5	903 3.2	518 2.5		1,342 85.9
<i>Cyprilla</i> sp. . . .					10,031 43.6	13,187 46.3	2,323 11.1	103 5.0	
<i>Cyprretta</i> sp. . . .					198 0.9				
<i>Pionocypris</i> sp. . .					495 2.2				
Total Ostracoda . . .			222 11.7	30 0.4	12,649 55.1	14,460 50.8	2,841 13.6	103 5.0	1,342 85.9
<i>Centroptilum excisum</i> .	15 4.2	148 6.7	44 2.3	237 3.5	374 1.6				
<i>Austrocaenis</i> sp. . .			30 1.6		484 2.1	370 1.2	562 2.7		
<i>Paragomphus cognatus</i>		15 0.7		15 0.2	33 0.1	15 0.1		44 2.1	
<i>Trithemis</i> spp. . . .			15 0.8		11 0.05		15 0.05		
Chironomidae	340 95.7	860 38.9	547 28.9	5,861 85.0	8,371 36.3	12,639 44.4	12,461 59.4	799 38.3	88 5.6
<i>Nilobezzia capensis</i> .			133 7.0	311 4.5	275 1.2	725 2.5	888 4.2	178 8.5	
<i>Dasyhelea</i> spp. . . .					803 3.5	30 0.1	44 0.2		
TOTAL	355	2,207	1,894	6,898	23,000	28,461	37,036	2,086	1,562

TABLE 35. PLANKTONIC ANIMALS FROM SANDY BOTTOMS AT PIKETBERG (STATION 18)

	September /sq. m. %	October /sq. m. %	November /sq. m. %	December /sq. m. %	January /sq. m. %	February /sq. m. %	March /sq. m. %	April /sq. m. %	August /sq. m. %
<i>Moina</i> sp.					66 16.7	59 1.2			
<i>Macrothrix</i> sp. . . .						533 10.8	30 7.0		
<i>Bosmina</i> sp.						1,658 33.5			
<i>Chydorus</i> sp.						59 1.2			
<i>Cyclops</i> spp.					330 83.3	2,634 53.3	400 93.7	59 100	
TOTAL					396	4,943	430	59	

TABLE 36. CHIRONOMIDAE IN SANDY BOTTOMS (STATION 18)

	1952				1953											
	September		October		November		December		January		February		March		April	
	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%	No. per sq. m.	%
Chironomini ^a	30	9.0	537	62.6	448	81.9	988	16.9	106	1.3	2,992	23.7	5,439	43.6	799	100
Tanytarsini mixed ^b	309	91.0	233	27.2	33	6.0	4,864	83.0	7,950	95.0	7,667	60.7	6,216	49.9		
Tanytarsini, <i>Zavrelia</i> type			59	6.3					106	1.3	187	1.5				
<i>Procladius</i>					50	9.1			58	0.7	49	0.3	720	5.8		
<i>Pentaneura</i>			35	4.1	17	3.1			116	1.3	10	0.1	76	0.6		

^a Mostly the *Cryptochironomus-Endochironomus* type of larvae, but some '*Stictochironomus*' in February.

^b Mostly '*Paratanytarsus*' type of larvae.

All the above determined from Hennig, 1950. The '*Zavrelia*' type of larvae had long tubular pre-anal papillae.

3. GENERAL CONSIDERATIONS

When comparing the fauna of these two stations it is not easy to distinguish zonal differences from the differences due to the slight organic pollution at Wellington. Though slight it certainly 'fertilized' the river and was probably responsible for the greater numbers of planktonic crustacea and the numbers of *Nais* sp. Zonal differences were probably: the presence of *Slavina appendiculata* at Wellington, the presence of large numbers of *Cyprilla* sp. at Station 18, and the large numbers of *Nilobezzia capensis* at Piketberg.

B. NOTES ON TRIBUTARIES OF THE GREAT BERG RIVER

Three tributaries are described and discussed, each differing markedly from the main river in any of its zones. The object of this section is not only to describe the distinctive faunas but also to relate faunistic differences to the distinctive environments. However, as each tributary differed from the main river in more than one respect, it was not easy to decide which environmental factor was mainly responsible for any particular difference in the fauna.

I. A SHADED FOREST STREAM AT ASSEGAIBOS (STATION 2). (Tables 37 and 38.)

At Assegaibos, in the upper Franschoek Forest Reserve, there is a small, permanent stream of the mountain torrent type. It differs from the main stream, near by, as it flows, for its whole length, through a strip of indigenous forest and the trees arch across the stream and cut off nearly all direct sunlight.

A sampling station (Station 2) was established on this stream at about the same altitude as Station 1 on the main river (fig. 2). Excluding the shade factor, the two streams resemble one another as they both consist of a series of runs, stickles and cascades, with pools in between. The stones in both are very clean with little sign of algal growth. However, the main river is larger and the tributary had no marginal growth of 'palmiet', *Prionium serratum*, because of the heavy shade.

The water in the tributary was very similar to that in the main stream (Table 5) except that the pH was always higher, though still in the acid range (Table 37).

The following are the characteristics which distinguish the Assegaibos stream from the main stream at Station 1:

- (a) The large amounts of leaf and twig remains caught between stones in the bed.
- (b) The continuous shade.
- (c) The lower summer temperatures and slightly higher winter temperatures (Table 37).
- (d) The higher pH. No readings below 6.0 were encountered, whereas, at Station 1 the pH dropped below 5.0 on occasions. (Tables 5 and 37.)

All of the above, except (d), were due to the shading trees. The higher pH was probably due to the fact that much water in the tributary came from soils derived from French Hoek Bed formations whereas all that in the main stream originated from Table Mountain sandstone.

TABLE 37. COMPARISON OF VALUES FOR TEMPERATURE, pH AND TOTAL DISSOLVED SOLIDS FOR STATIONS 1 AND 2

	7/6/50	23/6	19/7	2/8	18/8	30/8	27/9	24/10	30/10	10/11	24/11	14/12	13/1/51	5/2	26/2	5/3	12/3	11/4	16/5	13/6	16/8	
Temperature °C.																						
Station 1	13.0	10.8	9.0	8.9	12.0	12.0	11.5	11.5	15.0	14.0		18.0	17.8	20.8	22.0	18.0	21.8	16.8	13.0	11.5	10.5	
Station 2	14.0	13.9	12.3	12.6	13.0	13.2	13.0	12.0	14.2	15.0		16.0	16.0	16.5	16.2	15.0	16.2	14.8	14.2	13.5	12.8	
pH																						
Station 1					6.1		5.6				4.7				5.6			5.6		5.6	5.1	
Station 2					6.5		6.3	6.4			6.2			6.3	6.3			6.2		6.2	6.1	
T.D.S. p.p.m.																						
Station 1					10		36				33				35			40		22	18	
Station 2					27			17			32			13	38			50		45	32	

Only those values which were obtained on the same day are shown.

The Fauna

Only one type of habitat was sampled, namely, stones in runs and stickles; and the main constituents of the fauna are given in Table 38. This fauna should be compared with the fauna at Station 1 on the main river, shown in Tables 16 and 17.

TABLE 38. PERCENTAGE COMPOSITION OF THE FAUNA OF STONY RUNS AND STICKLES: ASSEGAIOS STREAM (STATION 2) (ONLY MAIN SPECIES SHOWN)

	Winter	Spring	Summer	Autumn	Winter
	1950 %	%	1950-1951 %	%	%
<i>Paramelita nigroculus</i>	4.6	6.1	1.4	0.8	0.9
<i>Aphanicercia</i> type nymphs	24.1	21.1	34.6	41.7	36.4
<i>Baetis harrisoni</i>	7.5	4.0	7.7	1.4	3.9
<i>Acentrella capensis</i>	6.8	4.0	2.7	3.1	7.9
<i>Abrionyx peterseni</i>	3.6	8.4	0.1	0.2	0.2
<i>Castanophlebia calida</i>	16.9	8.0	1.5	8.0	16.6
<i>Lithogloea pennicillata</i>	6.3	8.7	0.2	1.8	11.9
<i>Chloroniella peringueyi</i>	0.1	0.3	0.1	0.8	0.7
<i>Adicella</i> sp. 58A	0.4	4.5	1.7	—	—
<i>Myspoleo agilis</i>	—	2.1	0.1	0.2	—
<i>Cheumatopsyche maculata</i>	2.2	0.2	1.5	2.6	3.4
<i>Chimarra ambulans</i>	1.5	0.1	0.3	0.7	0.3
<i>Hydraenid</i> 145D	—	0.9	1.3	0.4	—
<i>Helodid</i> type A	1.8	4.0	2.8	1.2	3.5
" " B	1.1	0.3	0.1	1.0	—
" " C	1.6	—	—	0.3	1.3
Ptilodactilidae (larvae)	0.5	3.8	0.7	0.2	—
Helmid sp. 8J	0.2	0.2	0.2	0.5	0.5
Helmid sp. 6AA	4.9	4.7	2.3	7.1	1.1
<i>Limnophila nox</i>	0.6	0.4	0.5	—	—
Chironomidae	3.0	2.7	6.6	10.9	3.0
<i>Simulium</i> larvae	11.7	7.8	27.3	19.1	4.1
<i>Elporia uniradius</i>	0.7	1.3	—	—	0.6
<i>Atherix</i> spp.	1.1	0.9	0.1	0.3	0.7

There were marked differences between the fauna but it is not easy to associate these with any one of the factors above. It is obvious that all these factors must have been working in combination and that a much more detailed study would have been necessary to single out any as a limiting factor producing one particular change; but an attempt is made below to sort out the main effects of each.

(a) Leaf and twig remains caught between the stones. This would have modified the substratum; as for some animals vegetation provides a better hold-fast than stones. The constant falling in of leaves must also have supplied extra food material. The following features of the fauna at Station 2 appeared to be associated with this factor (comments in brackets are suggestions as to the means through which it was working):

1. The higher proportion of Nematouridae (more suitable substratum and food supply).
2. Presence of *Adicella* sp. 58A (more suitable substratum and food supply).

3. Higher numbers of *Cheumatopsyche maculata* (more suitable substratum for its web building and possibly an indirect improvement in its food supply).
4. Higher incidence of Ptilodactylidae (larvae) (more suitable substratum and possibly food supply).
5. Higher incidence of Chironomidae (mainly Orthocladiinae) (more suitable substratum and food supply).
6. Higher incidence of Simulium larvae (better food supply).
7. Higher incidence of Hydraenidae (substratum more suitable).

Though no quantitative samples were taken the higher incidences cited above were certainly due to greater numbers.

(b) Exclusion of direct sunlight. This would work directly on species which do not tolerate bright light and indirectly on species dependent on algae for food.

1. The only species of *Simulium* found here was *Simulium rutherfordi* which is only found in shady streams and not in the main river. This may be a case of habitat selection by the adult fly. It is not known what effects shade might have on the egg-laying habits of other adult insects.
2. The lack of light must have reduced the growth of diatoms and other algae. This could have reduced the numbers of *Baetis harrisoni*, *Aprionyx peterseni* and *Lithogloea pennicillata* all of which showed an incidence much lower than that in the main stream. Blepharoceridae may have also been affected in the same way, no *Elporia barnardi* were found though common at Station 1.

(c) Lower summer and autumn temperatures. These probably resulted in:

1. The constant presence of *Paramelita nigrocylus* (Gammaridae), though this species probably was also encouraged by factor (a).
2. The large numbers of Nemouridae present in summer and autumn.

(d) The higher pH. No direct link was apparent between this and any of the characteristics of the fauna. Though the pH was higher than at Station 1, it was still within the acid range.

There were other small differences between the faunas which were almost certainly linked with the factors above.

2. FAUNA OF A TEMPORARY STREAM. THE KUILS RIVER (STATION 17). (Tables 39 and 40.)

This is a small tributary of the lower Great Berg and it receives feeder streams from the near-by mountains and from low hills and farm lands composed of Malmesbury Series. The catchment is small and the stream is usually dry from December to March.

Samples were taken in a small stony stickle at a causeway, Station 17, figure 1. This patch of shaly stones was rather isolated from similar habitats as the stream bed was sandy for long distances above and below it. Thus it was in a similar position to the isolated series of stony runs and stickles formed by a shaly outcrop in the bed

of the main river near Piketberg, Station 18. Both these stations were situated in similar country, at similar altitudes and the water was subject to the same temperature range.

TABLE 39. KUILS RIVER (STATION 17): PHYSICAL AND CHEMICAL CONDITIONS.

	11/10/50	30/5/51	31/7	27/9	30/11	29/5/52
Temperature °C	29.0	13.0	9.0	16.5	27.0	—
Conduct. micromhos	300	440	2,200	900	280	275
Turbidity p.p.m. SiO ₂	12.5	—	11.5	14	38	—
pH (Phenol Red)	7.6	7.5	8.1	8.2	8.0	7.4
T.D.S. p.p.m.	340	—	2,612	1,115	313	—
Total Alkalinity (as CaCO ₃) p.p.m.	38.0	—	124.0	63.6	44.6	—
Total Hardness	79	—	824	330	86	—
Cl p.p.m.	128	196	1,366	538	119	—
SO ₄ p.p.m.	28.4	—	150	—	20	—

However, there were three main differences in the aquatic environment:

1. The chemical composition of the water. Values for total dissolved solids (and conductivity) were, on the whole, higher for the Kuils, especially when a high proportion of its water came from Malmesbury Series formations. This was the case in July when the lowland streams were running hard (Table 39). With these higher values went higher values for chlorides, sulphates, total alkalinity, total hardness, and pH. It is not considered that these differences would, in themselves, have had a marked effect on the fauna, as they were not very great except in July. At both stations the pH was in the neutral to alkaline range.
2. The temporary nature of the Kuils. The stream was dry from December to March and had to be recolonized every rainy season.
3. There was more filamentous algae growing on the stones in the Kuils than in the Great Berg. The growth was particularly thick in October and November and was mainly *Enteromorpha* sp.

The Fauna

Apart from an isolated sample in October 1950, sampling began late in April 1951 when the stream had not been flowing for more than four weeks and the flow was very slow. The last samples were taken at the end of November just before the stream dried up.

There was little sign of succession after the first colonization. No doubt this would have been apparent if frequent samples had been taken during the first few weeks after flow had resumed. Subsequent changes were due to variations in strength of river flow as the rainy season reached its maximum and then fell off. Similar seasonal changes occurred at Station 18 (Table 16). At both stations many animals were swept away by silt-laden flood waters.

First to colonize in large numbers were *Simulium* larvae, mostly *S. ruficorne* which thrives in slow-flowing water (Freeman and de Meillon, 1954, p. 99), and Chiro-

nomidae; there were also a few Baetidae. Flood conditions in July appeared to have been unfavourable to Baetidae.

There was a large increase in numbers with quieter spring conditions. This is not shown on the table as quantitative samples were not taken, but the increase was very obvious from the numbers in the qualitative samples. Conditions were again suitable for Baetidae.

TABLE 40. PERCENTAGE COMPOSITION OF THE FAUNA IN STONY STICKLES IN THE KUILS RIVER (STATION 17)

	11/10/50 %	26/4/51 %	21/7/51 %	30/10/51 %	30/11/51 %
<i>Nais</i> sp.	—	—	—	4.3	0.9
<i>Ferrissia</i> sp.	—	—	—	—	0.1
<i>Baetis harrisoni</i>	43.9	4.0	—	57.9	0.2
<i>Baetis</i> sp. A	5.5	0.8	—	—	—
<i>Baetis</i> sp. B	—	—	—	12.8	31.8
<i>Centroptilum excisum</i>	1.3	2.4	—	1.2	2.8
<i>Austrocaenis</i> sp.	0.2	2.4	—	1.7	—
Gyrinid larvae, probably <i>Aulonogyrus</i> spp. (a)	2.9	—	3.8	0.6	—
Hydraenids 108 G	3.7	—	—	—	—
<i>Simulium</i> larvae	22.4	70.4 (b)	46.2	7.6	44.5 (c)
Chironomidae	17.7	16.0	42.3	14.9	15.6

(Note: *Potamon perlatum* was present on all occasions.)

- (a) On 11/10/50, 23 adults were taken; they were: 4 *Aulonogyrus alternatus* Règ., 12 *A. marginatus* Aubè and 7 *A. splendidulus* Aubè.
 (b) Mostly *Simulium ruficornes*.
 (c) This included 16 pupae, 7 *S. ruficornes* and 9 *S. adersi*.

When comparing this fauna with that at Station 18 on the main river, the following features stand out:

- (a) The total absence of *Tricorythus discolor* in the Kuils.
 (b) The total absence of *Cheumatopsyche zuluensis* in the Kuils.
 (c) The replacement of *Baetis harrisoni* by *B. sp. B* in the Kuils shortly before the stream dried up.

Both *T. discolor* and *Ch. zuluensis* were abundant at Station 18, especially in spring (see Tables 47 and 48). Their absence in the Kuils must have been due to their inability to colonize a temporary stream. The replacement of *Baetis harrisoni* by *B. sp. B* was probably due to the appearance of thick algal growths on the stones in November and the very slow flow. It will be noticed in Table 40 that the common species of *Simulium* in the Kuils were *S. ruficornes* and *S. adersi* whereas Figure 12 shows that *S. bovis* was the characteristic species at Station 18, no reason can be advanced for this difference, though Lewis as quoted by Freeman and de Meillon, 1954, p. 202, states that in the Sudan *S. bovis* is to be found in rivers rather than streams.

3. THE SOUT RIVER, HOPEFIELD, A STRONGLY SALINE, TEMPORARY STREAM
(STATION 20). (Tables 41 and 42.)

This is the lowest tributary of the Great Berg and flows into the Flood Plain Zone (Zone V) just above Station 21.

TABLE 41. SOUT RIVER, HOPEFIELD (STATION 20): PHYSICAL AND
CHEMICAL CONDITIONS

	24/4/51	25/6/51	29/8/51	31/10/51
Temperature °C.	24.5	15.8	18.2	27.0
Conductivity micromhos	4,500	3,400	4,500	5,200
Turbidity p.p.m. SiO ₂	4.5	14.0	—	0.0
pH (Phenol Red)	8.4	8.2	8.2	8.4
T.D.S. p.p.m.	8,648	5,355	7,958	—
Total alkalinity (as p.p.m. CaCO ₃)	159.6	137.6	206.0	224.0
Total Hardness (as p.p.m. CaCO ₃)	—	—	184.0	—
Cl as p.p.m.	4,560	2,920	3,730	7,300
SO ₄ as p.p.m.	650	230	—	—

It differs from the main stream in the following ways:

1. It is a temporary stream. It was dry from December to March.
2. It is very saline. It derives most of its water from Malmesbury Series deposits which are rich in dissolved solids. Table 41 shows that these were mainly chlorides though the sulphates and alkalinities were also high. In October 1952, when the stream was drying up, the chloride concentration was nearly half that of sea water. The pH was always well in the alkaline range. The water was far more saline than that of the near-by Diep River which is described by Millard and Scott (1954). There the total dissolved solids range from 300 to 1,800 p.p.m.
3. The flow was very slow. The rainfall over the catchment area is of the order of 12 to 14 inches per annum so even the wet season flow is slow, though there are occasional floods. At Station 20 the bed was broad and shallow and the banks low and sloping, so even the effects of floods were minimized. On the four occasions, when samples were taken, the flow was barely detectable.

At Station 20 the broad bed was floored with sand and the banks were mainly sandy beaches broken here and there by patches of coarse grass (*Paspalum* sp.) and Cyperaceae and Juncaceae. In August and October there were large patches of filamentous algae along the margins (mainly *Enteromorpha* sp.).

Millard and Scott (1954) describe a certain amount of aquatic vegetation from the near-by Diep River, mainly *Aponogeton* spp. but there was none in the Sout. The Diep is also temporary and *Aponogeton* spp. do thrive in temporary waters, but it would seem that the high salinities of the Sout would prevent its growth.

The Fauna (Table 42)

Samples were taken among the marginal vegetation and filamentous alga.

The April sample was taken about three weeks after the flow had recommenced. Nymphs of *Cloeon lacunosum*, *Ischnura senegalensis* and *Libellulidae* were already present

but the bulk of the fauna in the sample consisted of adult Notonectidae, Corixidae, Dytiscidae and Hydrophyllidae, which could have flown there. Numbers of *Berosus* spp. (Hydrophyllidae) were seen and caught on the wing. During the wet season the numbers of aquatic nymphs and larvae increased but *Cloeon lacunosum* remained the only Baetid present.

TABLE 42. PERCENTAGE COMPOSITION OF THE FAUNA IN MARGINAL VEGETATION, IN THE SOUT RIVER, HOPEFIELD (STATION 20)

	24/4/51 Flow: slow	25/6/51 Flow: slow	30/8/51 Flow: slow	31/10/51 Flow: almost stopped
	%	%	%	%
<i>Chiltonia capensis</i>			1.6	
<i>Potomon perlatus</i>	present	present	present	present
<i>Cloeon lacunosum</i>	9.6	44.6	4.7	27.0
<i>Ischnura</i> sp.	5.3		0.8	
Libellulid nymphs (probably <i>Sympetrum fons-</i> <i>colombi</i>)	1.1			0.9
<i>Anisops aglaia</i> Hutch.	1.1			
<i>Anisops poweri</i> Hutch.	5.3			
<i>Anisops</i> nymphs, probably mostly <i>A. poweri</i>	13.8			
<i>Sigara meridionalis</i> (Wallgr.)	17.0	1.4		
<i>Micronecta winifredii</i> (Hutch.)	2.1	21.6	6.2	
<i>Micronecta bleekiana</i> Hutch.		1.4		
<i>Micronecta scutellaris</i> (Stål.)		1.4	0.8	47.3
<i>Berosus australis</i> (Péring)	13.8			
<i>Berosus spretus</i> J.B.-B.	3.2			
<i>Ochthebius extremis</i> (Péring.)	13.8			
<i>Potomonectes capensis</i> O.-C.	6.4	6.8	1.6	0.5
Dytiscid larvae			6.2	4.5
Chironomidae	1.1	18.9	21.7	18.9
<i>Culex</i> sp.			54.3	

The type of fauna present would seem to be due to three main factors: the temporary nature of the stream, the very slow flow, and the high pH.

The temporary nature of the stream leads to the succession of fauna apparent from Table 42. Most temporary ponds, dams and vleis in the neighbourhood show the same succession; colonization in large numbers by flying adults of Notonectidae, Corixidae, and water beetles, followed by a falling off of these and an increase in aquatic nymphs and larvae. Many of these other temporary waters have aquatic snails which can withstand desiccation to some extent but drought conditions in the Sout at Hopefield were too severe for them.

The very slow flow led to the absence of true riverine forms. It was not rapid enough to encourage *Simulium* spp. not even *S. ruficorne*, although this was present in the near-by Diep River. Both the Diep and the Great Berg in Zone V supported a number of riverine Baetidae (*Baetis bellus*, *B.* sp. B, *Pseudocloeon vinosum* and *Centropitulum excisum*), but there the flow was often fairly strong.

The high pH influenced the type of still-water species which colonized the Sout. *Cloeon lacunosum*, *Ischnura senegalensis*, *Anisops agalaia* and *Sigara meridionalis* are typical species of alkaline standing waters in the district, both temporary and permanent.

Waters in the acid to weakly alkaline range have other species. These faunas are to be discussed in a later paper.

The effects of the high salinity are not obvious and may have been obscured by the other factors. In the upper estuary of the Great Berg there are three species of Amphipoda which were fairly abundant about three or four miles below the farm Kersefontein (Station 21). If this stream had been permanent it seems likely that these would have migrated up to Station 20 and established a permanent colony. One of them, *Chiltonia capensis*, was found in small numbers at Hopefield in August 1951 (Table 42).

C. NOTES ON THE FAUNA OF THE GREAT BERG RIVER

This section gives further information on dominant, 'significant' (see Part 1) or interesting species. The animals are dealt with in systematic order; but information available in Part 1 is not repeated though page and table references are given for the sake of completeness. Station numbers are given on the map (fig. 1).

The following is a summary of the Zones used and the sampling stations on them.

Zone I. Cliff waterfalls and 'Sponges'. (No regular sampling stations.)

Zone II. Mountain Torrent Zone (Station 1).

Zone IIIA. Upper Foot-hill Stony Run Zone (Stations 3 and 5).

Zone IIIB. Lower Foot-hill Stony Run Zone (Stations 9, 10, 11 and 12).

Zone IV. Foot-hill, Soft Bottom Zone (Stations 13, 14, 16, 18 and 19).

Zone V. Flood Plain Zone (Station 21).

As many species are still unidentified or undescribed, a catalogue number or other designation is used for them. It is hoped to publish a complete systematic list when all the names are available.

HYDROIDA

Hydra sp. Occurs in sandy backwaters (Tables 20 and 21). A few were also found in stony backwaters at Stations 9 and 10 in summer and autumn.

TURBELLARIA

Planarians: Table 15.

NEMERTEA

Prostoma sp. Tables 15, 16, 19, 20, 22-24.

CRUSTACEA

Potamon perlatus M. Edw. This crab was seen regularly in all zones of the river, from the Mountain Torrent to the Estuary. It was noted that those seen in the upper zone were, usually much smaller than those seen in Zones IIIB to V. They did not occur regularly in samples because of their cryptic and semi-terrestrial habits.

TABLE 43. DENSITY OF NEMOURIDAE IN STONY RUNS AND STICKLES EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951					1952									
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.
ZONE II															
Station 1															
Type A		18	29	87	33	79	86	86	94	76	76	18	72		
Type B		—	—	—	—	—	—	4	29	4	7	—	—		
ZONE IIIA															
Station 3															
Type A	29	18	4	36	97	61	62	29	36	43	113	36	—		
Type B	4	—	—	—	—	—	—	—	18	40	32	—	—		
Station 5															
Type A	72	4	—	22	11	101	4	—	4	7	190	216	104		
Type B	—	—	—	—	—	—	—	—	4	25	158	119	7		
ZONE IIIB															
Station 9															
Type A	14	—	7	4	—	—	—	—	11	—	29	47	18	7	
Type B	—	—	—	—	4	—	11	—	—	29	22	4	—	—	
Station 10															
Type A	—	—	4	4	—	—	—	—	—	—	4	4	11	—	
Type B	—	—	—	—	—	—	—	—	—	4	7	—	4	—	
Station 11															
Type A			—	—									7	—	
Type B			—	—									—	—	
Station 12															
Type A	—	—	—	—			—	—	—	4	1,064	4	22	7	11
Type B	—	—	—	—			22	—	—	7	86	—	—	—	—

Station 12, April 1953—type A 28, type B 5.
 Type A: *Aphanicerca-Aphaniceropsis*-type of nymph. Type B: *Aphanicerella*-type of nymph.
 Blank: no samples. Dash: none in samples.

INSECTA

Nemouridae

Table 43 gives the numbers of individuals per square metre of stony bottom, caught by the Surber sampler. (Part 1, page 176 et seq.).

Type A nymphs (*Aphanicerca* sp. *Aphanicercopsis* sp. and *Desmonemoura* sp.). At Station 1 numbers were at a more constant level than lower down and were at a maximum during summer and autumn months. However, there were also short August and November maxima.

At Stations 3 and 5 there were more distinct summer and winter maxima which were more obvious at the lower station. At Station 9 there was only a winter maximum and at Station 10 numbers were negligible.

The large number at Station 12 (Wellington) in June 1952 was unexpected. There had been practically no winter rain up to the time of sampling, a very unusual occurrence, and the river was running slowly with no silt. Slight organic pollution had resulted in an ample food supply. Qualitative samples taken during June 1951, a normally wet month, contained very few nymphs. This difference may indicate the part played by silt-laden waters in limiting the Nemouridae to the upper reaches of the river in normal years.

Adults of the following species were captured: *Aphanicerca capensis* Tillyard, *Aphanicercopsis hawaquae* Barnard, and *Desmonemoura pulchellum* Tillyard. The two former were widespread but the latter was not found below Station 3. The winter maximum seems to be mainly due to the two former and *D. pulchellum* contributes to the summer peak at the upper stations.

Type B nymphs (*Aphanicercella* spp.). These showed one maximum only at Station 1; this occurred in April but at the lower stations was more distinctly a late autumn-winter maximum. The greatest densities were encountered at Station 5 (Zone IIIA). Possible reasons for the unusual numbers at Station 12 in June 1952 are discussed above in connection with Type A nymphs; the 22 per cent in February 1953 do not fit into the general picture. At the time the river was very low and conditions appeared most unfavourable.

Species present were: *Aphanicercella scutata*, Barnard, *A. barnardi* Tillyard, *A. bifurcata* Barnard and *A. quadrata* Barnard. *A. barnardi* was the most widespread species.

For further information on distribution see Tables 15 to 19 and 23 and 24.

*Ephemeroptera**Heptageniidae*

Afronurus harrisoni Barnard. Stony runs and stickles and stony backwaters. Tables 16 and 19.

Baetidae of stony runs and stickles

Table 44 gives the density per square metre of *Baetis harrisoni* Barnard, *Baetis* sp. A and *Acentrella capensis* Barnard, as calculated from the monthly samples. For further information see Tables 16 and 17.

TABLE 44. DENSITY OF BAETIS HARRISONI, BAETIS SP. A AND ACENTRELLA CAPENSIS IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951		1952											1953							
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
ZONE II																					
Station 1																					
<i>B. harrisoni</i>		4	25	36	18	342	641	590	676	29	360	76	24								
<i>A. capensis</i>		58	18	—	3	36	32	—	—	—	7	7	36								
ZONE IIIA																					
Station 3																					
<i>B. harrisoni</i>	165	115	173	72	72	173	76	18	58	72	360	18									
<i>A. capensis</i>	—	22	7	—	4	—	4	—	—	11	7	14									
Station 5																					
<i>B. harrisoni</i>	403	828	670	598	580	47	22	14	166	169	313	259	382								
<i>A. capensis</i>	—	11	—	11	7	43	14	—	7	11	7	4	7								
ZONE IIIB																					
Station 9																					
<i>B. harrisoni</i>	252	670	961	853	227	245	97	29	7	154	194	360	432	565							
<i>A. capensis</i>	—	14	58	—	14	14	—	—	—	—	7	4	54	4							
Station 10																					
<i>B. harrisoni</i>	158	216	486	209	169	169	—	—	65	7	108	58	217	202							
<i>B. sp. A</i>	—	—	4	—	—	—	—	—	14	—	—	7	—	—							
<i>A. capensis</i>	—	32	—	—	11	4	—	—	—	—	—	—	4	—							
Station 12																					
<i>B. harrisoni</i>		1,223	1,792	66			—	11	292	184	704	695	544	233	706	148	612	36	60	324	38
<i>B. sp. A</i>		11	17	3			—	—	—	148	259	11	14	—	14	—	83	—	—	—	5
<i>A. capensis</i>		17	22	—			—	—	—	4	—	7	47	11	18	—	11	—	—	—	—
ZONE IV																					
Station 18																					
<i>B. harrisoni</i>		4	18	7					5	—	4		104	43	14	7	119	11	—	—	—
<i>B. sp. A</i>		180	7						90	7	—		18	252	158	4	22	—	—	29	4

Blank: No samples. Dash: None in samples.

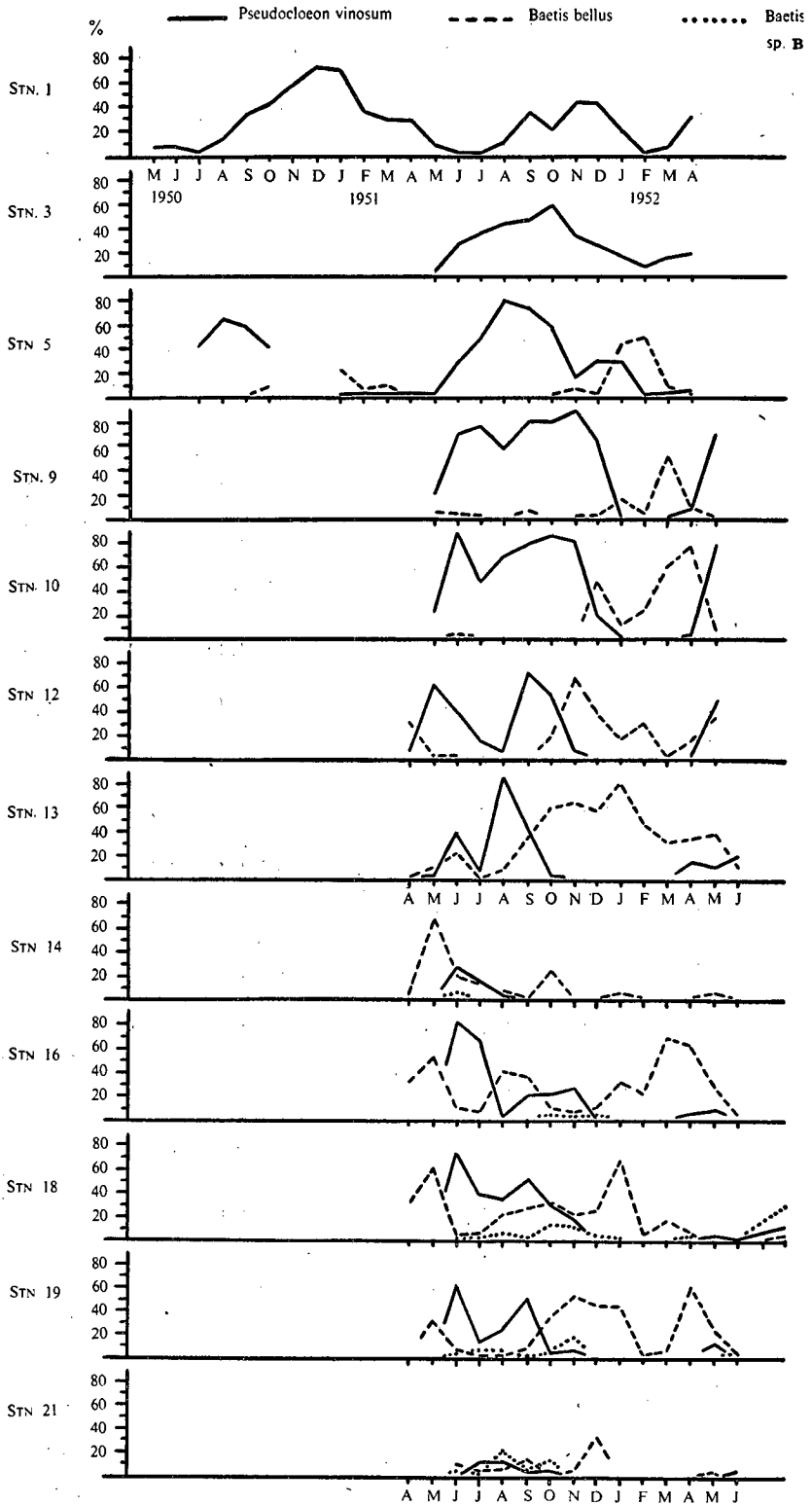


FIG. 6. Monthly percentage incidence of common Baetidae in the fauna of marginal vegetation (*Baetis bellus*, *Baetis* sp. B and *Pseudocloeon vinosum*.)

Baetis harrisoni. At Station 1 numbers were highest in summer and autumn. The high June density was probably due to the lack of the usual June flooding. At Station 3 densities were at their lowest for the whole upper part of the river, the high June figure again being due to lack of flooding. At Station 5 and in Zone IIIB the species was at its maximum during winter and spring. The very large numbers at Station 12 in spring, 1952, were linked with a slight organic pollution there. At Piketberg (Station 18) it was less common.

Baetis sp. A. A lower river species, its highest densities were at Station 12 in May and June and at Station 18 in spring. Figures indicated that it could not tolerate the summer months as well as *B. harrisoni*.

Acentrella capensis. The density of this species was never high. The patchy figures may have been due to periodic ecdyses of whole batches of nymphs. It did not penetrate into Zone IV.

Pseudocloeon maculosum Crass. This was sometimes common at Stations 12 and 18 but its occurrence was very patchy. Station 12: June 1952—146/sq.m., November—7/sq.m., December—226/sq.m., February 1953—49/sq.m., and April—16/sq.m. Station 18: May 1952—28/sq.m., November—7/sq.m., December—104/sq.m., January 1953—25/sq.m., February—22/sq.m., and March—266/sq.m.

All these Baetids have short life-cycles and it is possible that large batches mature together. A sampling after a hatch would show very few individuals. The first few instars from newly laid eggs would have passed through the net. This was seen to happen at Station 1 in May 1952, where there were a few large but numerous minute nymphs crawling on the stones.

Baetidae of marginal vegetation

The seasonal picture is given in Tables 23 and 24. Figure 6 gives a month-by-month picture of the percentage composition. *Pseudocloeon vinosum* Barnard was universal in the winter but somewhat less important from Station 12 downstream where *Baetis bellus* was common. The summer and autumn gaps at the lower stations are very apparent, especially at Stations 14 and 21 where the flow was very slow.

Baetis bellus Barnard was better able to stand summer conditions in the lower zones. The distribution of these two species is discussed in Part 1, page 221.

Baetidae of backwaters

Figure 7 shows the limited distribution of *Pseudocloeon* sp. A. It showed a maximum incidence in spring of both years. The month-by-month incidence of *Centroptilum excisum* Barnard was very irregular. See Tables 18 and 19, also for *C. excisum* 20 and 21.

Leptophlebiidae of stony backwaters

Figure 8 shows clearly how *Aprionyx tabularis* (Eaton) replaces *A. peterseni* (Lest.) at Station 5. The incidence below this station was very low.

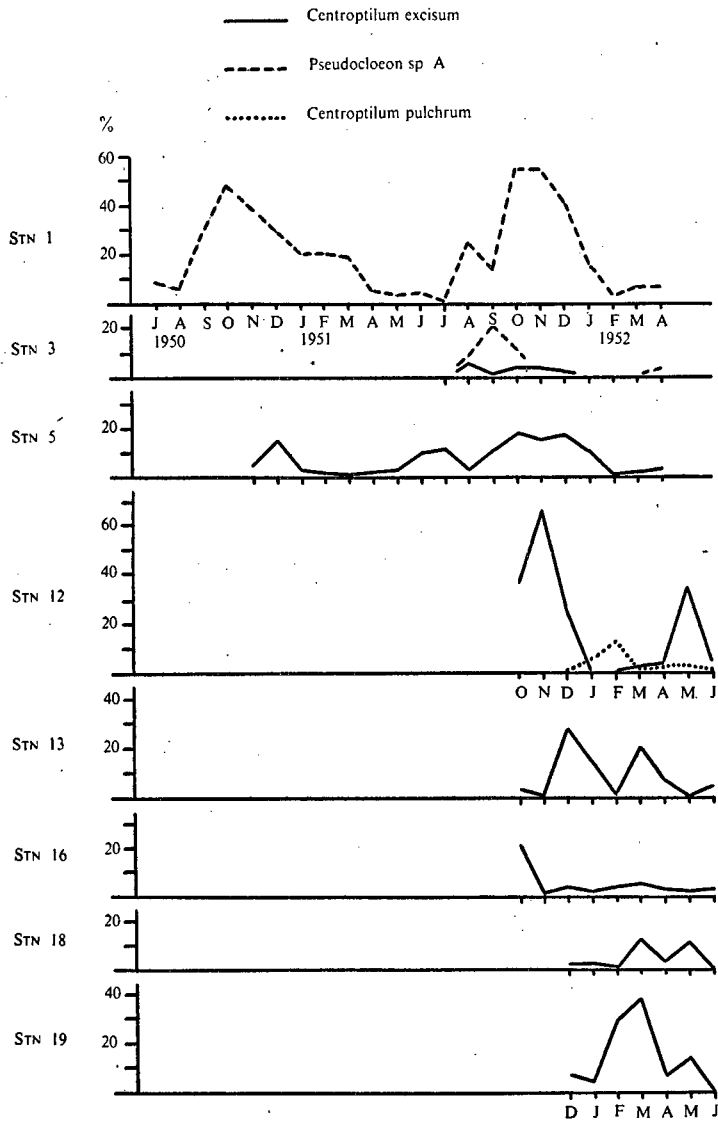


FIG. 7. Monthly percentage incidence of the Baetidae in backwaters (*Pseudocloeon* sp. A, *Centropilum excisum* and *C. pulchrum*).

The month-by-month incidence of *A. peterseni* is somewhat irregular as imagines appear and breed throughout the year. *A. tabularis*, the 'March Brown', produces only one generation a year and most adults appear during March (Barnard, 1932). *Aprionyx intermedius* Barnard would appear to produce several generations a year. See Tables 18 and 19.

Leptophlebiidae of runs and stickles (Table 45)

At Station 1 *A. peterseni* was important in this biotope, especially during the drier months of December to April. However, it showed itself capable of with-

TABLE 45. DENSITY OF LEPTOPHLEBIIDAE IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951 August	Sept.	Oct.	Nov.	Dec.	1952 Jan.	Feb.	March	April	May	June	July	August
ZONE II													
Station 1													
<i>Aprionyx peterseni</i>		43	32	64	112	108	216	140	208	47	29	6	29
<i>A. intermedius</i>		—	—	—	—	—	—	—	94	4	7	112	—
<i>Castanophlebia calida</i>		93	104	93	79	61	7	14	108	—	70	—	86
ZONE IIIA													
Station 3													
<i>Aprionyx peterseni</i>	14	14	4	7	—	4	7	50	11	4	11	22	—
<i>A. intermedius</i>	—	—	—	—	—	—	—	—	25	4	4	—	—
<i>Castanophlebia calida</i>	18	22	4	4	14	4	4	11	79	40	90	29	—
Station 5													
<i>Aprionyx peterseni</i>	—	4	—	—	—	—	—	—	—	—	—	—	—
<i>A. intermedius</i>	4	—	—	—	—	—	—	—	—	11	11	22	—
<i>Castanophlebia calida</i>	18	18	4	4	4	7	—	—	11	32	32	14	7

These species were insignificant below Station 5.

Blank: No samples. Dash: None in samples.

TABLE 46. DENSITY OF EPHEMERELLIDAE IN STONY RUNS AND STICKLES EXPRESSED AS INDIVIDUALS PER SQUARE METRE

	1951					1952								
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.
ZONE II														
Station 1														
<i>Lithogloea pennicillata</i>		266	198	135	97	4	7	108	396	299	436	364	623	
<i>L. harrisoni</i>		—	—	4	—	—	4	—	14	4	4	1	—	
ZONE IIIA														
Station 3														
<i>L. pennicillata</i>	151	129	119	14	4	—	—	11	54	58	144	50		
<i>L. harrisoni</i>	54	65	43	61	54	14	22	11	36	11	137	79		
Station 5														
<i>L. pennicillata</i>	30	29	22	—	—	—	—	—	—	11	7	14	22	
<i>L. harrisoni</i>	68	180	155	30	18	4	—	—	4	11	80	40	29	
ZONE IIIB														
Station 9														
<i>L. pennicillata</i>	36	14	4	—	—	—	—	7	11	7	18	—	7	47
<i>L. harrisoni</i>	50	94	36	—	11	—	—	—	—	—	11	—	104	—
Station 10														
<i>L. pennicillata</i>	—	—	4	—	—	—	—	—	—	—	4	—	—	—
<i>L. harrisoni</i>	11	7	4	—	—	—	—	—	—	—	—	—	4	4

These species were insignificant below Station 10.

Blank: no samples. Dash: none in samples.

Castanophlebia calida Barnard also declined in Zone IIIA and numbers were negligible below Station 5 though a few were found as far down as Station 12 during the wet months. See Tables 15 to 17.

Ephemerellidae in runs and stickles (Table 46)

Lithogloea pennicillata Barnard was common at Station 1 and fairly common at Station 3 but below this numbers fell off. It produces only one generation a year and most adults appear during December. Early instars were found in early January both in stickles and in stony backwaters at Station 1.

Lithogloea harrisoni Barnard was commonest in this biotope at Stations 3 and 5. Adults appeared at all times of the year. See also Tables 15 to 17.

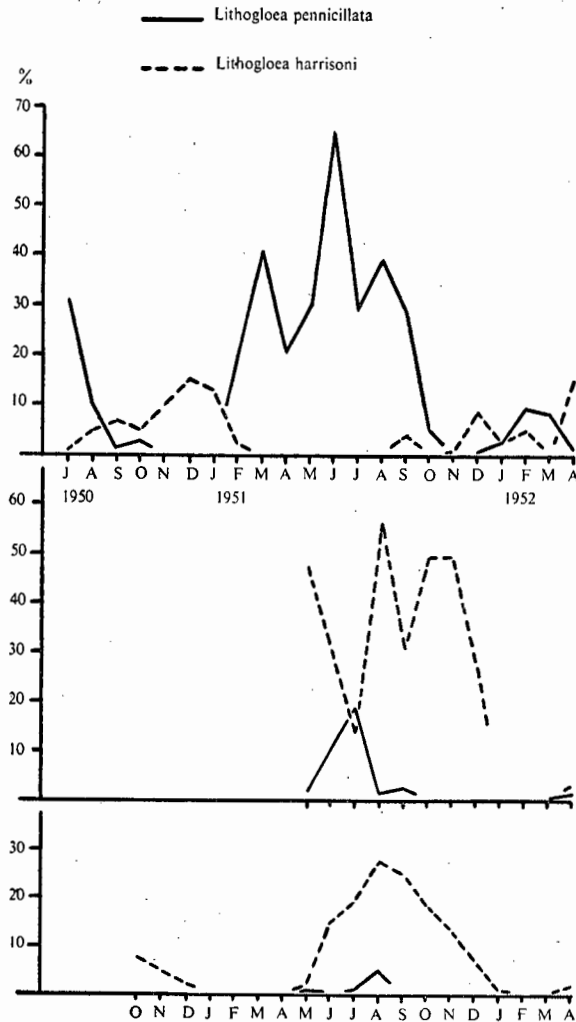


FIG. 9. Monthly percentage incidence of *Lithogloea* spp. in the fauna of stony backwaters. (There were very few in backwaters below Station 5.)

Ephemerellidae of stony backwaters (Figure 9)

L. pennicillata, mainly a running-water species, was common in backwaters at Station 1 during the wet months. Here the backwaters were small, clean and frequently scoured out by floods. The low autumn incidence in 1952 was linked with an exceptionally low rainfall. At Station 3 *L. harrisoni* practically dominated the backwater fauna in winter and spring. It was also common at Station 5 but there it was rather overshadowed by *Aprionyx tabularis* (Fig. 8).

See also Tables 18 and 19.

Other Ephemerellidae

Lithogloea sp. A. This occurred in *Scirpus digitatus*, Tables 25 and 26.

Lithogloea sp. B. This appeared in small numbers in stony runs and stickles at Stations 3 and 5 in winter and spring. Nymphs were also found in the Mountain Torrent Zone (Zone II), in winter, spring and summer, living in the aquatic moss, *Wardia hygrometrica*. They are mentioned by Barnard, 1940, under *L. harrisoni*, as 'nymphs of a uniform very dark Vandyke brown, almost black'.

Ephemerellina barnardi Lestage. Nymphs were fairly common among stones in the upper part of the Mountain Torrent Zone when visited in spring and summer. Lower down they were found among *Scirpus digitatus*. Tables 25 and 26.

Tricorythidae

Tricorythus discolor Burmeister (Table 47). At Station 18 there was a sudden outburst of *Tricorythus discolor* in October 1953, after which there was a steady decline in density. Fewer were recorded for October 1952, when samples were taken in coarse gravel and not among stones. A few odd individuals were found at Station 12 in summer and autumn, and, in February 1952, at Stations 9 and 5. Tables 15 and 16.

Caenidae

Very few nymphs of the type described for *Austrocaenis capensis* Barnard were taken in the Great Berg, and those mostly in Zone IIIB. The majority were of a very much smaller type. For density in runs and stickles see Table 47. Highest densities were recorded during the dry months, especially February, very few were recorded from this biotope above Station 12. See also Tables 15 and 16. They were also found in: stony backwaters, Tables 18 and 19; soft bottoms, Tables 20 and 21 and section A of this part; marginal vegetation, Tables 23 and 24.

Zygoptera

Chlorolestes conspicua. *Chlorolestes* nymphs were found at Station 1 during the drier months, in backwaters which had been completely isolated from the main river but not in those connected to it. Upstream, where the mountain valley narrowed into a ravine, they were found in spring and summer in connected backwaters and other quiet parts of the stream. They were very characteristic of the pools below

TABLE 47. DENSITY OF TRICORYTHUS DISCOLOR AND AUSTROCAENIS SP. IN STONY RUNS AND STICKLES,
EXPRESSED AS INDIVIDUALS PER SQUARE METRE

	1951				1952								1953							
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
ZONE III B																				
Station 12																				
<i>Tricorythus discolor</i>
<i>Austrocaenis</i> sp.	.	19	2	.	.	—	43	—	40	76	29	11	4	4	7	36	4	108	43	11
ZONE IV																				
Station 18																				
<i>Tricorythus discolor</i>	.	—	36	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Austrocaenis</i> sp.	.	11	7	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

These species were insignificant above Station 12 though *Austrocaenis* sp. was common in other habitats.

Blank: no samples. Dash: none in samples.

cliff waterfalls. This distribution is similar to that given by Barnard (1937). The few nymphs bred out were *C. conspicua* but further breeding would probably have revealed other species.

Lestes sp. A few nymphs were found in a backwater of the small Kuilers River, a tributary entering near Station 19. They were not correlated.

Pseudagrion spp. Nymphs were a feature of the fauna of marginal vegetation of the whole river, Tables 23 and 24. A number of adults were caught. From these it would appear that *Pseudagrion kersteni* (Gerst.) var. *draconis* Barnard was the commonest species in all zones of the river. Apart from these one *P. kersteni* s. str. was caught at Station 18 and one *P. caffrum* (Burm.) at Station 3.

Enallagma sp. Nymphs resembling those of this genus, were found in marginal vegetation at Station 13 in spring. None was bred out and no adults were caught in the vicinity. A few adult *Enallagma glaucum* (Burm.) were caught at Station 19. This species appears to favour still water.

Occasional nymphs of *Elatoneura* sp. were found at Station 3, mainly in the *Scirpus digitatus*. Adults of *Elatoneura frenulata* (Hagen, Selys) were caught near by.

Anisoptera

Paragomphus cognatus (Rambur). A species of sandy bottoms. See Tables 19, 20 and 21 and 16; also section A in this part.

Ceratogomphus pictus Selys. Nymphs were numerous in a large pool formed by an irrigation barrage on the Klein Berg, near Gouda. (See map, fig. 1.) They were living in a bottom composed of deep mud, but they were not found in similar muddy bottoms at Station 14 on the main river, near by. A number of nymphs were bred out to confirm Barnard (1937).

Aeschna minuscula McLach. This occurred in stony runs and stickles, see Tables 15 and 16, also 19.

Trithemis spp. Nymphs appeared in Zones III and IV in summer in a variety of habitats, all of them sheltered. There were fewer in autumn and hardly any in winter and spring. See Tables 19, 21, 22 and 24; also section A of this part.

No nymphs were bred out but adults were very common especially in Zones III and IV. Those captured were mainly *Trithemis risi* Longfd. and *T. arteriosa* (Burm.). There were also a few *T. ardens* (Gerst.).

Though numbers of adult *Orthetrum* spp. were seen, especially in Zones III and IV, nymphs were very seldom encountered. These have cryptic habits and seek refuge in crevices between roots and similar places and may have been commoner than would appear from the samples. One adult *O. farinosum* Forster was taken at Station 10 in February 1953.

Pseudomacromia sp. Nymphs similar to those described by Barnard (1937) were found in small numbers in the *Scirpus digitatus* at Station 3 in autumn. They were occasionally found in stony runs and stickles from Stations 3 to 10 in summer and autumn.

Corixidae

Micronecta spp. Figure 10 shows the monthly incidence of *Micronecta* spp. in the fauna of sandy backwaters. See also Tables 18, 19, 20-22, 23 and 24 and section A of this part.

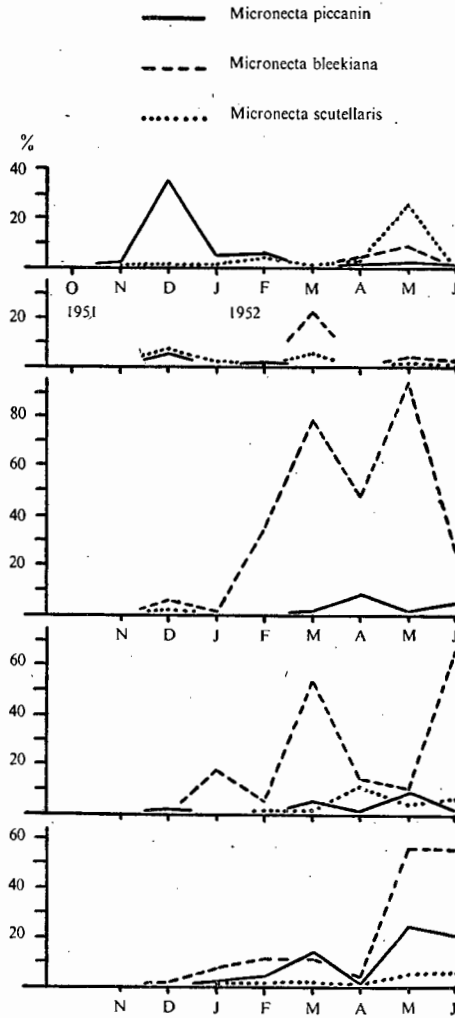


FIG. 10. Monthly percentage incidence of *Micronecta* spp. in the fauna of shallow sandy backwaters.

Micronecta piccanin Hutch. had an irregular distribution in the river. Its favourite habitat is the extreme inch or two of the margin, so it can be easily missed when netting. It was the only species found above Station 12 and a few were even

found at Station 1. *M. bleekiana* Hutch. was especially characteristic of Zones IV and V. After becoming common at the lower stations in December and January (fig. 7) numbers increased and it spread upstream to appear at Wellington (Station 12) in April and May. Winter floods practically swept it out of Zone IV but it remained common in Zone V (Station 21). See Part 1, page 195.

Micronecta scutellaris (Stål.) had a somewhat irregular incidence from Station 12 downstream. This is mainly a species of still waters. *Micronecta winifredi* Hutch. was found regularly in summer at Station 19 but numbers were small. See Part 1, page 195.

Notonectinae

Nychia limpida (Stål.) was found in marginal vegetation samples. See Tables 23 and 24. It could be seen hovering in fairly deep, quiet pools near to clumps of 'palmiet' and was caught when the hand-net was swept in and out of this vegetation.

Anisops aglaia Hutch. appeared in fair numbers at Stations 14 and 16 when water was being drained out of the irrigation dam near Gouda, it is a species of alkaline standing waters. See Table 29 and Part 1, page 206. See also Section B 3 of this part, Sout River.

Pleinae

Plea pullula Stål. Occurred in marginal vegetation, see Table 24.

Plea piccanina Hutch. A few specimens were found from time to time at Station 12 in marginal vegetation. Both species prefer standing water.

Naucoridae

Laccocoris limnogenus Stål. See Tables 23 and 24.

Ranatridae

Single individuals, mainly nymphs, appeared regularly in samples from marginal vegetation at Station 19 in summer. One adult taken was *Ranatra cinnamomea* Distant.

Veliidae

These surface skaters were common from Station 1 down to Station 21. They were often very abundant locally in sheltered spots, especially from Stations 12 to 19. Two species were distributed throughout, a larger, *Rhagovelia nigricans* Burm., and a smaller, *Microvelia* (*Stenovelia*) *lansburyi* Hoberlandt.

Gerridae

Occasional individuals were found throughout but they were sometimes locally common in sheltered places. Specimens caught were of only one species: *Gerris swakopensis* Stål.

Megaloptera

Sialidae

One small larva of *Leptosialis* sp. was caught in a backwater at Station 9 on November 26, 1953. The Great Berg is obviously quite unsuitable for them.

Corydalidae

Chloroniella peringueyi Esb.-Pet. See Tables 15, 16, 18 and 19. Though this was found in small numbers in samples from stony runs and stickles it was always conspicuous by its large size.

Platychnauliodes sp. Larvae similar to those described by Barnard (1931) for *Taeniochnauliodes ochraceopennis* were found occasionally in runs and stickles from Stations 1 to 5, mainly in summer. As they were different in some important respects, it is suggested that they were larvae of *Platychnauliodes*, probably *P. capensis* from the little that is known of its distribution (Barnard 1931). Unfortunately no adults were caught.

Taeniochnauliodes ochraceopennis Esb.-Pet. Barnard (1931) found this species high up in mountain streams and rapids so it was not expected at any of the regular sampling stations. One larva was found at Station 1. Numbers of larvae occurred in samples taken near the top of the Mountain Torrent Zone (over 4,500 feet) in spring and summer. They were also found in pools at the base of cliff waterfalls.

*Trichoptera**Sericostomatidae*

Petroplax spp. See Tables 16, 18 and 19. Larvae were usually found in stony-sandy backwaters at Stations 3 and 5 in spring and autumn. It is felt that a thorough search would have revealed them in summer and winter as well though they did not appear in the regular samples. Larvae and pupae were collected by Scott (1955) from these sites and bred out in the laboratory. Most of them were *Petroplax curvicosta* Scott but some pupae from Station 5 were *Petroplax prionii* Barnard.

Barbarochthon brunneum Barnard. See Tables 15, 16, 23 to 26. An upper river species, mainly found in vegetation.

Molannidae

Petrothrincus circularis Barnard. A few were found in stony stickles and backwaters at Station 5 in summer.

Petrothrincus triangularis Barnard. A number were found in samples from stony habitats taken from the upper part of the Mountain Torrent Zone in spring and summer. They appeared to be quite common there. They did not get down to Station 1.

Leptoceridae

Athripsodes harrisoni Barnard. See Tables 23 to 25.

Athripsodes schoenobates Barnard. See Tables 24 and 26. Most were found in *Scirpus digitatus* which was their food plant. Some large specimens were found living among palmiet at Station 5. Their cases were made of dead pieces of palmiet and in an aquarium they ate dead palmiet leaves.

Athripsodes sp. larvae similar to *scramasax* (Barnard). See Tables 16, 18, 19, 23 to 25. This is a new species and is being described by Dr. K. M. F. Scott.

Athripsodes sp. A. These were swimming larvae with a short case made of pieces of dead palmiet. See Tables 23 and 24.

Athripsodes sp. B. These larvae had a spiral, sand-grain case, rather like that of *Helicopsyche*. They were found in Zone IIIA in summer and autumn. They seemed to prefer the extreme margins of clean stony backwaters or the sheltered margins of stony runs and stickles. Because of this, not many appeared in the samples. Tables 19 and 24. This new species is being described by Dr. K. M. F. Scott as *Leptecho* sp. See Addendum.

Athripsodes sp. C. Larvae in sand grain case, see Table 16.

Athripsodes sp. D. Larvae in sand grain case, see Tables 24 and 26.

Oecetis modesta (Barnard) (as *Potamoryza*). Table 16.

Hydropsychinae

Cheumatopsyche maculata Moseley (= *Hydropsychodes lateralis* Barnard). See Tables 15 to 17.

Cheumatopsyche zuluensis (Barnard). See Tables 15 and 16. Pupae from Station 18 were correlated in the laboratory.

Table 48 gives the number of the two above species found, month by month, in the runs and stickles. The highest densities of *C. maculata* were recorded from Station 5, especially from January to June. *C. zuluensis* was only found at Station 18, and the unbroken series of samples from August 1952 to April 1953 show its seasonal variation. A few appeared in September, the maximum density was reached in February and the autumn decline began before the first floods of the rainy season.

Sciadorus sp. Larvae were fairly common in the upper parts of the Mountain Torrent Zone, above Station 1. They were found in spring and summer among *Scirpus digitatus* and *Wardia hygrometrica*. Barnard (1934) reports *S. acutus* Barnard from this region.

Psychomyidae

A few larvae similar to those of *Ecnomus* spp. were found at Station 12 and lower stations in summer and autumn. They only appeared regularly in marginal vegetation samples from Station 16 (Table 24).

Polycentropidae

Protodipseudopsis sp. Larvae inhabited sheltered areas at Stations 3, 5 and 9, where they could construct their soft rambling tubes which were usually fixed to stones in backwaters. They were not found in large numbers but their size made them conspicuous. (Tables 18 and 19.) This species is being described by Dr. K. M. F. Scott.

Philopotamidae

Chimarra ambulans Barnard. Larvae were found among stones in the current (Tables 15 and 16.)

TABLE 48. DENSITY OF CHEUMATOPSYCHE SPP. IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951					1952								1953								
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	
ZONE II																						
Station 1																						
<i>C. maculata</i>	.		—	—	—	—	47	22	7	14	—	4	—	—								
ZONE IIIA																						
Station 3																						
<i>C. maculata</i>	.	—	14	4	32	25	68	97	54	108	—	4	11									
Station 5																						
<i>C. maculata</i>	.	22	7	36	4	25	284	68	158	119	61	137	4	4								
ZONE IIIB																						
Station 9																						
<i>C. maculata</i>	.	7	—	—	11	11	14	11	25	35	7	62	—	7	—							
Station 10																						
<i>C. maculata</i>	.	—	—	—	—	25	11	72	25	11	—	4	—	—	—							
Station 12																						
<i>C. maculata</i>	.		—	—	—			32	14	—	—	—	—	—	—	—	14	—	6	—	—	
ZONE IV																						
Station 18																						
<i>C. maculata</i>	.	—	—	—						—	—	—	—	—	<i>p</i>	<i>p</i>	65	7	—	—	—	
<i>C. zuluensis</i>	.	—	—	—						652	—	4	—	—	4	162	148	605	670	972	295	29

p: a few *C. maculata* were present but were not separated from *C. zuluensis*; the figures given for the latter would have been for both species combined.

Blank: no samples. Dash: none in samples.

Rhyacophilidae

Myspolec agilis Barnard. Larvae were found among stones in the current. (Tables 15 and 16.)

Hydroptilidae

Hydroptila capensis Barnard. Larvae were seldom found in large numbers and always in association with *Spirogyra* from which they construct their cases. Wherever this occurred larvae were liable to appear as well in any region of the river. Unusual numbers, 2830/sq.m., were found in stony stickles at Station 12 in March 1953. The river was very low and slight organic pollution had encouraged the growth of *Spirogyra* among the stones. (Tables 19, 21 and 24.)

Hydroptila sp. A. This species has a bivalve case made of small sand grains. (See Barnard, 1934, fig. 51j.) A few were found in stickles at Station 3 in autumn and in backwaters there in spring and summer. Though rare in the Great Berg, they are common in some Natal and Transvaal rivers.

Argyrobothrus velocipes Barnard. This was common among marginal vegetation but with a patchy distribution. (Tables 23 and 24.)

Hydroptilid with 'caraway seed' case, Barnard, 1934, fig. 51k. This was mainly found among stones in the current. It was probably more common than samples indicated as many were small enough to pass through the net used. (Tables 15, 16, 24 and 26.)

*Lepidoptera**Pyralidae*

Larvae, probably *Nymphula* sp., were common in patches of *Scirpus digitatus* which was their food plant. (Tables 25 and 26.)

*Coleoptera**Dytiscidae*

Yola harrisoni Omer-Cooper. These were found from Station 12 downstream in small numbers, usually in backwaters. (Table 21.)

Clypeodytes sp. These were found in small numbers in backwaters at Station 3 in summer. (Table 19.) (Probably *C. meridionalis* R eg.)

Hydrophilidae

Berosus sp. See Table 24 and Section B 3 of this part.

Helochaes sp. See Table 24.

Paracyamus sp. See Table 24.

The above three types were 'strays' from dams, ponds and vleis where they are common.

Hydrochus gemmatus. See Table 24. A few were found at the farm Kersfontein, Station 21, but they were common in some temporary vleis, ponds and streams in the area (Millard and Scott, 1954).

Hydraenidae

Sp. 8K. See Tables 16 and 24.

Sp. 6Y. See Tables 16 and 24.

Sp. 1Q. See Table 16.

Sp. 145D. See Table 16.

Though there were numbers of species recorded from the upper parts of the river, the above were the only ones which occurred in the samples with any regularity. Species 8K is very small and many would have passed through the meshes of the net used. From other observations and from a few samples taken with a finer net, it would appear to be common in Zones II and III at most times of the year.

Species 6Y occurred in small numbers at Station 1 at all times of the year. Its appearance lower down at Stations 12 and 14 (Table 24) may have been due to winter flooding. Species 1Q and 145D were Zone II species, the latter was small enough to pass through the net used.

Species 520 M. See Table 16.

Species 409A. See Table 16.

Species 239F. See Table 24.

Hydraenidae were very rare in samples from the two lower zones (IV and V), but a few were found in autumn and winter. Species 520M was fairly common in the runs and stickles at Station 12 in autumn, 409A in runs and stickles at Station 18 in autumn, and 239F in the marginal vegetation at Stations 16 and 19 in winter.

Limnebius sp. This very small species was found living in the surface film at the extreme margins or on floating leaves and emergent vegetation. It was often found among leaves and pebbles at the extreme margin of the faster parts of the stream. Because of its size and habitat it was usually missed by the net but turned up in a few samples taken at Station 16 in autumn.

Other observations indicated that it was fairly common from Stations 16 to 19 during the dry season.

Helodidae (Larvae)

Species A. See Tables 16, 19, 24 and 26.

Species B. See Tables 16, 19 and 26.

Species C. See Tables 16, 19 and 24.

Helodidae were almost entirely limited to Zones II and IIIA and species A was found in a stream in a Sponge in Zone I. Species A preferred stony habitats though it was also found in marginal vegetation. Species B showed a strong preference for stones in the current and Species C for marginal vegetation.

Dryopidae

Strina sp. 7U. See Tables 16 and 26. It occurred in Zones II and IIIA.

Species 128A. See Table 26. This species was practically limited to *Scirpus digitatus*. Individuals were not very numerous in those parts of the weed trailing in

TABLE 49. DENSITY OF LARVAE AND ADULTS OF HELMID SPECIES 8J IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951					1952								
	August	Sept.	October	Nov.	Dec.	January	February	March	April	May	June	July	August	Sept.
ZONE II														
Station 1														
Larvae		4	—	4	4	—	—	—	25	—	—	4	34	
Adults	—	—	—	—	—	29	40	14	11	4	—	—	7	
ZONE IIIA														
Station 3														
Larvae	—	4	7	14	4	29	43	108	389	65	104	40		
Adults	4	79	47	263	90	50	25	36	22	11	11	32		
Station 5														
Larvae	4	7	—	4	—	43	61	97	133	135	486	11	7	
Adults	—	7	36	47	43	148	101	189	50	—	4	4	14	
ZONE IIIB														
Station 9														
Larvae	—	4	—	7	7	14	11	7	7	43	133	—	—	—
Adults	—	4	—	7	11	29	11	32	7	7	11	4	4	—
Station 10														
Larvae	—	—	—	—	—	—	4	7	—	7	14	4	—	—
Adults	—	—	—	—	—	4	4	—	4	4	4	—	—	—

This species was insignificant below Station 10.

Blank: no samples. Dash: none in samples.

TABLE 50. DENSITY OF LARVAE AND ADULTS OF HELMID SPECIES 6AA IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951 August	Sept.	October	Nov.	Dec.	1952 January	February	March	April	May	June	July	August	Sept.
ZONE II														
Station 1														
Larvae		11	2	18	14	22	58	65	101	169	101	24	18	
Adults		—	—	—	—	151	126	140	24	22	7	4	—	
ZONE IIIA														
Station 3														
Larvae	14	25	22	43	191	68	36	90	220	270	194	32		
Adults	14	7	—	—	7	43	22	54	58	25	162	11		
Station 5														
Larvae	7	4	14	36	25	40	205	187	86	108	24	18	11	
Adults	4	7	4	22	30	86	115	137	79	32	18	14	—	
ZONE IIIB														
Station 9														
Larvae	—	—	4	—	—	18	7	4	22	29	4	—	—	4
Adults	—	—	—	18	40	29	11	40	4	—	—	—	—	—
Station 10														
Larvae	—	—	—	4	—	—	7	—	7	—	—	—	—	—
Adults	—	—	4	4	7	4	7	—	7	—	—	—	—	—

This species was insignificant below Station 10.

Blank: no sample.

Dash: none in sample.

the strong current but, where it grew in backwaters or pools, they were often abundant.

In the upper parts of Zone II there were a few other common species of *Strina*.

Helmidae

Species 8J (*Helmis* sp.). See Tables 16, 17, 24 and 26. Table 49 gives the numbers of adults and larvae in the stony runs and stickles. Adults were commonest in Zone IIIA (Stations 3 and 5). The maximum incidence of adults at Station 3 (November and December) came earlier than that at Station 5 (January and March). The larval maximum followed and was again a bit later at Station 5.

Species 6AA (*Limnius* sp.). See Tables 16, 17, 19, 24 and 26. Table 50 gives the numbers of adults and larvae in stony runs and stickles. This species was more at home at Station 1 than Species 8J but also had its highest incidences in Zone IIIA, especially as regards the larvae. Some larvae recorded may have been those of Species 125E but as this is a very small species and not very common, it is considered that most of its larvae would have passed through the net, so all larvae were taken as being those of Species 6AA.

Maximum larval incidences did not follow the adult maxima except at Station 1. The species was commonest during the dry season; figures were high in June 1952, but this was probably because the usual heavy rains did not fall.

Species 125E (*Limnius* sp.). See Tables 16 and 26. A very small species.

Species 230C. See Table 19. A very small species.

Species 3M. See Table 26.

Species 81B. See Table 16. Samples taken in spring and summer in the upper parts of Zone II contained a number of these indicating that they were common at the top of this zone.

Gyrinidae

Larvae. See Tables 16, 24. From the adults caught it would appear that most of these larvae were of *Aulonogyrys* spp.

Adults. Table 51 gives the locations of the adult Gyrinidae caught in the river. (See also Table 40.) The first three species on the table would seem to be confined to the upper parts of the river, the second three would appear to be fairly universal, except in Zone V. The last two would appear to be lower river species, especially *A. alternatus*. *A. capensis* was the commonest species in Zones II and IIIA and B.

Gyrinus vicinus. This species was common in standing waters near by, and a few were occasionally found in sheltered spots along the river. It is not a riverine species.

Further information on the Gyrinidae of this region is given by Brinck, 1955.

Diptera

Blepharoceridae

Elporia barnardi (Edw.). See Tables 16 and 17.

Elporia uniradius Brnrd. See Tables 16 and 38.

TABLE 51. DISTRIBUTION OF ADULT GYRINIDAE

	ZONE II	ZONE IIIA		ZONE IIIB			ZONE IV				ZONE V
	Stn. 1 and other points	Stn. 3	Stn. 5	Stn. 10	Stn. 11	Stn. 12	Stn. 13	Stn. 14	Stn. 18	Stn. 19	Stn. 21
<i>Orectogyrus conformis</i> Rfg.	—	1	—	3	—	—	—	—	—	—	—
<i>Aulonogyrus formosis</i> Modeer	—	—	1	—	1	—	—	—	—	—	—
<i>Aulonogyrus varians</i> Brnk. var. <i>hottentotus</i> Brnk.	—	8	—	—	1	—	—	—	1	—	—
<i>A. splendidulus</i> Aubé	16	—	—	—	1	1	—	—	1	1	—
<i>A. marginatus</i> Aubé	11	—	—	—	1	—	—	—	1	—	—
<i>A. capensis</i> Thunb.	10	21	87	36	76	4	25	—	3	2	—
<i>A. alternatus</i> Ræg.	—	—	—	4	9	—	26	—	15	5	17
<i>A. abdominalis</i> Aubé	—	—	—	1	—	—	—	1	—	1	—

The table shows the total numbers collected. Identifications by Dr. P. Brinck.

Two other species, *E. spinulosa* Edw. and *E. capensis* Edw., were found to be fairly common in the uppermost parts of the Mountain Torrent Zone when visited in spring and summer. Barnard (1947) reports further species from the Western Cape Province mountains.

Tipulidae

Limnophila nox Alex. See Tables 16 and 38.

Limonia tipulipes (Karsch). See Table 24.

Dixidae

Dixa sp. See Tables 23 and 24. From larvae bred out there appeared to be only one species, *Dixa bicolor* Wood.

Psychoda alternata. This was sometimes found at Station 12 when there was some organic pollution. See Part 4 of this series.

A number of new species were collected by Dr. G. Satchell near the cliff waterfalls, where they were probably breeding in wet or damp moss. He is describing these.

Culicidae

These were rare in the river though abundant in near-by rain-water or flood-water pools. Larvae of *Culex* sp. were found in small numbers in the marginal vegetation at Station 12 in winter. (Table 24.) It is likely that they had been swept there when floods had washed out near-by isolated pools. Some bred out were identified as *Culex pipiens*. A few larvae and pupae of *Anopheles listeri* were found in the marginal vegetation at Piketberg in March 1952. They were common in flood-water pools there in March 1953. The distribution of the species of Culecidae in the Western Cape Province is dealt with by Muspratt.

Simuliidae

Simulium larvae and pupae were found practically universally on all substrata in the current. Odd individuals were found in backwaters after floods. See Tables 15, 16, 17, 23, 24, 25 and 26.

Table 52 gives the density on stony bottoms as determined by the Surbur sampler. There was a tendency for numbers to increase downstream from Station 1 to Station 12. The highest densities were found during the dry months when flows were comparatively slow and regular.

The very high numbers at Station 12 in March 1952 and 1953 were linked with organic pollution there; this will be discussed in Part 4 of this series.

Larvae could not be identified but pupae could. All species mentioned were bred out and later identified by Dr. B. de Meillon. (See also Freeman and de Meillon, 1953.)

No substratum preferences were found and records from all biotopes are combined in figure 11. The only possible exception was *S. hessei* which was found in small torrents and waterfalls and not in the normal runs and stickles and on trailing vegetation.

TABLE 52. DENSITY OF SIMULIUM LARVAE AND PUPAE IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBER OF INDIVIDUALS PER SQUARE METRE

	1951					1952								1953							
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
ZONE II																					
Station 1		4	32	50	7	43	14	14	47	50	28	22	3								
ZONE IIIA																					
Station 3	22	277	166	54	105	43	47	4	158	58	14	176									
Station 5	47	34	180	318	422	177	187	162	1,955	51	383	98	116								
ZONE IIIB																					
Station 9	87	7	734	122	1,129	1,721	2,180	360	30	11	379	91	51	66							
Station 10	32	15	93	93	84	385	76	82	1,423	4	213	97	54								
Station 12		16	29	86			3,987	83,700	7,048	36	1,853	4	44	22	3,316	22	159	7	2,819	10,149	32
ZONE IV																					
Station 18		4	—	—					43	—	130		198	54	4	—	4	—	32	151	36

Blank: no samples. Dash: none in sample.

		ZONES		IIIA			IIIB			IV		
		II	3	5	9	10	12	13	14	16	18	19
		STN.	1									
<i>Simulium medusaeformis</i> Pomeroy	Spring		█	█	█	█	█					
	Summer		█	█	█	█	█					
	Autumn		█	█	█	█	█					
	Winter		█	█	█	█	█					
<i>Simulium hessei</i> Fr and de M	Spring											
	Summer		█									
	Autumn											
	Winter		█									
<i>Simulium harrisoni</i> de M	Spring		█	█	█	█	█					
	Summer			█	█	█	█					
	Autumn			█	█	█	█					
	Winter			█	█	█	█					
<i>Simulium impukane</i> de M	Spring			█								
	Summer					█		█				
	Autumn			█	█	█	█					
	Winter				█							
<i>Simulium merops</i> de M	Spring											
	Summer		█	█								
	Autumn		█	█								
	Winter				█							
<i>Simulium unicornutum</i> Pomeroy	Spring						█					
	Summer			█	█	█	█	█				
	Autumn			█	█	█	█	█				
	Winter						█					
<i>Simulium adersi</i> Pomeroy	Spring						█					
	Summer						█					
	Autumn						█	█				
	Winter			█								
<i>Simulium nigritarsis</i> Coquillet	Spring			█	█	█	█					
	Summer			█	█	█	█					
	Autumn				█							█
	Winter						█					
<i>Simulium ruficornis</i> Macquart	Spring											
	Summer					█	█					
	Autumn					█	█				█	
	Winter										█	
<i>Simulium bovis</i> de M	Spring										█	
	Summer										█	
	Autumn									█	█	█
	Winter										█	█

FIG. 11. Distribution of *Simulium* spp. based on records from all habitats.

Figure 11 shows that most species were found in Zones IIIA and B and that four species, *S. harrisoni*, *S. impukane*, *S. merops* and *S. unicornatum*, seemed to be limited to this part of the river. It should be noted, however, that pupal records for the upper part of Zone IV (Stations 13 to 16) were rather meagre. *S. hessei* was limited to Zone II but *S. medusaeformis* was the common species there, and it extended down to Station 12. *S. adersi* was found mainly in Zone IIIB; *S. ruficorne* and *S. nigritaris* were found both in Zone IIIB and IV. *S. bovis* was limited to Zone IV.

No pupal records were obtained from Stations 14 and 21 where there were very few larvae.

A number of seasonal changes were apparent: during the dry months most species, except *S. medusaeformis* and *S. harrisoni*, were more widely collected than during the wet months, though this may have been due to the fact that fewer pupae were taken during the wet months, mainly because there were fewer available. Species characteristic of Zones IIIA and B (see above) were much more restricted to the upper part of their range in autumn than in summer. Species characteristic of Zones IIIB and IV (see above) showed their widest distribution in autumn.

Two further species, found in tributaries only, were: *S. rutherfordi* de M. found in a shaded stream in Zone II (Station 2, Section B 1 of this part); *Cnephia harrisoni* Freeman and de Meillon, found in a shaded mountain stream at Tulbagh, a tributary of the Klein Berg River (Great Winterhoek Mountains). They were abundant in September 1951.

Chironomidae

Larvae and pupae were found commonly in most habitats. See Tables 14 to 26; also Sections A 1 and 2, of this part, especially Tables 33 and 36 and Sections B 1, 2 and 3.

Table 53 gives the density in runs and stickles. It should be noted that many smaller larvae, such as those of *Thienemanniella* spp., would have passed through the meshes of the net. This was seen to happen at Station 1.

Generally, there was an increase downstream and larvae and pupae were more abundant during the drier months when the flow was slower and more even. However, at Stations 5 to 18 there were also distinct spring maxima.

Exceptionally high numbers were recorded from Station 12 from time to time. These were linked with organic pollution and are to be dealt with in Part 4 of this series.

The systematics of the adults collected from the vicinity of the river are dealt with by Freeman, 1953 A and B, 1954 A and B. Dr. K. M. F. Scott has studied the distribution of species based on adults netted along the river banks or bred out from samples of larvae. (Part 3 of this series.)

Ceratopogonidae

Nilbezzia capensis de M. See Tables 20 and 21 and Section 1 A and B of this part. The larvae are described by Mayer, 1955, pp. 113-15.

TABLE 53. DENSITY OF CHIRONOMIDAE (LARVAE AND PUPAE) IN STONY RUNS AND STICKLES, EXPRESSED AS NUMBERS OF INDIVIDUALS PER SQUARE METRE

	1951					1952								1953								
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	
ZONE II																						
Station 1 . . .		4	—	8	—	4	4	180	79	4	4	—	7									
ZONE IIIA																						
Station 3 . . .	—	32	7	4	36	65	227	360	130	14	32	14										
Station 5 . . .	29	11	7	137	76	144	216	72	202	22	65	58	29									
ZONE IIIB																						
Station 9 . . .	83	43	122	522	461	180	194	80	65	11	281	115	25	32								
Station 10 . . .	29	14	334	414	72	191	209	230	580	—	40	4	32	4								
Station 12 . . .		200	92				194	583	702	540	1,620	101	40	11	562	97	382	72	2,036	216	220	
ZONE IV																						
Station 18 . . .		54	50	580						91	83	43		14	14	281	54	432	256	626	130	54

Blank: no samples. Dash: none in samples.

Dasyhelea spp. See Section A 2, Table 34. Larvae were common in damp river-side and sand and in the sandy margins of sheltered parts from Stations 12 to 19. They were too small to be held by the normal hand-net but appeared in the fine-net samples. Judging by adults caught and pupae bred out, most of them were larvae of *Dasyhelea inconspicua* C.I. and M. (See Mayer, 1955, p. 107.)

Atrichopogon victoriae de M. See Table 16. Larvae were fairly common in stony runs at Station 18 in summer; there were also a few at Station 12. These larvae are described by Mayer, 1955, pp. 104 to 107.

Numerous adults of *Dasyhelea* spp. and many other genera were netted alongside the river in all reaches of the river. As larvae did not appear in the river itself it is assumed that many must have lived in the damp sand and soil of the river banks.

Leptidae

Atherix spp. etc. See Tables 15 and 16. Adults captured at Station 2 were *Atherix androgyna* Bezzi and *A. barnardi* Bezzi. A number taken above Station 1 were *Pachybates braunsi* (Bequaert).

Empidae

Clinocerinae. See Tables 15, 16. Apart from those recorded at Stations 5 and 9 on the tables, a few were also found at Stations 10, 11 and 12.

Tabanidae

See Tables 15, 16. Larvae were found in small numbers in stony runs at Station 3 in autumn and winter.

Sciomyzidae

Larvae similar to *Sepedon* were found in samples taken from sandy margins at Station 19 in autumn. They were probably strays from damp marginal sand.

HYDRACHNELLAE

These were not often found in the coarse-net samples but fine-net samples showed that they were common in stony runs and stickles from Zones II to IV. They were also found among marginal vegetation and in backwaters. See Table 18. Samples from various parts of the river were sent to Dr. K. Viets who gives a full account of the species present and their distribution (Viets, 1956).

PISCES

See Part I, Section I.

ANEURA

Frog and toad tadpoles were occasionally encountered in samples. Tadpoles of *Heleophryne rosei* were taken on rare occasions in Zone II (see Rose, 1950). These attach themselves to stones and rocks by means of their sucker-like mouths.

Small tadpoles were found at Station 16 in marginal vegetation in spring and in sandy backwaters in summer.

This paper is published with the permission of the South African Council for Scientific and Industrial Research.

ADDENDUM

Since going to press the following names have become available:

Athripsodes bergensis Scott for *Athripsodes* sp. *scramasax*-type, or near *scramasax*.

Athripsodes prionii Scott for *Athripsodes* sp. A.

Leptecho helicotheca Scott for *Athripsodes* sp. B.

Petroplax curvicauda Scott (young larvae) for *Athripsodes* sp. C.

Adicella sp. for *Athripsodes* sp. D.

REFERENCES

- Barnard, K. H. 1931. 'The Cape Alder-flies (Neuroptera, Megaloptera).' *Trans. Roy. Soc. S.A.*, xix, 169-84.
- 1932. 'South African May-flies (Ephemeroptera).' *Trans. Roy. Soc. S.A.*, xx, 201-99.
- 1934A. 'South African Caddis-flies (Trichoptera).' *Trans. Roy. Soc. S.A.*, xxi, 291-394.
- 1934B. 'South African Stone-flies (Perlaria) with descriptions of new species.' *Ann. S.A. Mus.*, xxx (17), 511-48.
- 1937. 'Notes on Dragon-flies (Odonata) of the S.W. Cape, with descriptions of nymphs and of new species.' *Ann. S.A. Mus.*, xxxii (12), 169-260.
- 1940. 'Additional records and descriptions of new species of South African Alder-flies (Megaloptera), May-flies (Ephemeroptera), Caddis-flies (Trichoptera), Stone-flies (Perlaria), and Dragon-flies (Odonata).' *Ann. S.A. Mus.*, xxxii, Part 6, 609-61.
- 1947. 'The Blepharoceridae (Diptera) of the S.W. Cape.' *J. Ent. Soc. S.A.*, x, Part 2.
- Brinck, Per. 1955. 'Gyrinidae. A Monograph of the Whirligig Beetles of Southern Africa.' *South African Animal Life*, vol. I, pp. 329-518, Uppsala.
- Freeman, P., and de Meillon, B. 1953. 'Simuliidae of the Ethiopian Region.' *British Museum*, London.
- Freeman, P. 1953A. 'Chironomidae (Diptera) from Western Cape Province—I.' *Proc. R. Ent. Soc. London* (B), 22, 127-35.
- 1953B. 'Chironomidae (Diptera) from Western Cape Province—II.' *Proc. R. Ent. Soc. London* (B), 201-13.
- 1954A. 'Chironomidae (Diptera) from Western Cape Province—III.' *Proc. R. Ent. Soc. London* (B), 23, 17-25.
- 1954B. 'Chironomidae (Diptera) from Western Cape Province—IV.' *Proc. R. Ent. Soc. London* (B), 23, 172-80.
- Hennig, W. 1950. *Die Larvenformen der Dipteren*, Berlin.
- Mayer, K. 1955. 'Beitrag zur Ökologie und Morphologie afrikanischer Heleiden (Dipt.).' *Arch. f. Hydrobiol.*, 51, 1, 98-117.
- Millard, N. A. H., and Scott, K. M. F. 1954. 'The Ecology of South African Estuaries. Part VI, Milnerton Estuary and the Diep River Cape.' *Trans. Roy. Soc. S.A.*, xxxiv.
- Muspratt, J. 1953A. 'Research on South African Culicini (Diptera, Culicidae). I. Description of two *Aedes* (*Ochlerotatus*) Lynch Arribalzaga.' *J. Ent. Soc. S. Afr.*, 16 (1), 51-8.
- 1953B. 'Research on South African Culicini (Diptera, Culicidae). II. Taxonomy relating to eight species of *Aedes*.' *J. Ent. Soc. S. Afr.*, 16 (2), 83-93.
- 1956A. 'The *Stegomyia* mosquitoes of South Africa and some neighbouring territories.' *Memoirs Ent. Soc. S. Afric.*, No. 4.
- 1956B. 'Research on South African Culicini (Diptera, Culicidae). III. A check-list of the species and their distribution, with notes on taxonomy, bionomics and identification.' *J. Ent. Soc. S. Afr.*, 18 (2), 149-207.
- Rose, W. 1950. *The Reptiles and Amphibians of Southern Africa*, Cape Town.

- Scott, K. M. F. 1955. 'Some new Caddis-flies (Trichoptera) from the Western Cape Province—I.' *Ann. S.A. Mus.*, xli, 6.
- Some new Caddis Flies (Trichoptera) from the Western Cape Province—II. *Ann. S. Afr. Mus.* (in press).
- Viets, K. 1956. 'Wassermilben aus Südafrika. Systematische, faunistische und ökologische Untersuchungen.' *Zool. Jb. (Systematik)*, 84 (1), 1-31.

HYDROBIOLOGICAL STUDIES ON THE GREAT BERG RIVER, WESTERN CAPE PROVINCE

PART 4

The effects of organic pollution on the fauna of parts of the Great Berg River
System and of the Krom Stream, Stellenbosch.

By A. D. HARRISON

National Chemical Research Laboratory

SUMMARY

The effects of mild organic pollution on the invertebrate fauna of the Great Berg River in the Paarl-Wellington region are described and also the conditions in a polluted tributary, the Dwars River. Serious organic pollution, largely from distillery wastes, was encountered in the Krom Stream, Stellenbosch; the drastic changes in the composition of the bottom fauna are described and related to changes in water quality. There is a discussion on the effects of different degrees of organic pollution on the faunal associations of various biotopes and reasons are advanced for the changes encountered, 'indicator species' are also discussed. Conditions found in South Africa so far are compared with those reported from other parts.

CONTENTS

	PAGE		PAGE
INTRODUCTION	299	DISCUSSION	322
Mild organic pollution of the Great Berg River	301	The effects of mild pollution	322
Sources of pollution	301	The effects of serious pollution.	323
The effects of pollution on water quality	301	Indicator animals for fast-flowing streams	324
Effects of pollution on the fauna	303	A comparison of South African con- ditions with those reported else- where	325
Organic pollution of the Dwars River, Groot Drakenstein	310	Pollution effects encountered and the 'Saprobic Zones'	326
Mild to heavy pollution in the Krom Stream, Stellenbosch	312	APPENDIX 1	327
Sources of pollution	313	APPENDIX 2	328
Description of stations	315	REFERENCES	329
The effects of pollution	315	ACKNOWLEDGEMENT	329
Water quality	315		
Effects on the fauna.	318		

INTRODUCTION

An account of the normal fauna of the Great Berg is given in Parts 1, 2 and 3, and the object of this part is to describe changes in the fauna arising from organic pollution of varying severity.

The first section deals with the effects of fairly mild organic pollution of the Great Berg in the vicinity of Paarl and Wellington, and the second with a similar pollution of the Dwars, a tributary at Groot Drakenstein (see Part 1, fig. 2). As no really heavy pollution was encountered in the Great Berg system, a special study was made on the polluted Krom Stream, a tributary of the Eerste River at Stellenbosch (see fig. 2 and fig. 15). The results of this are given in section 3.

All the instances of contamination by organic matter, described below, have been grouped under the term 'pollution'. Perhaps the inclusion of cases of mild contamination could be disputed as the use of the water would not appear to have been limited in any way, either for domestic, industrial, agricultural, recreational or any other legitimate purposes. These instances might, at first sight, appear to be no more than 'fertilizations' of the river. However, the type of chemical and biological assessment used during these studies does not give the whole picture. For instance, pollution which produced mild chemical and biological effects in the Paarl region during winter was due to small inflows of raw sewage; if the bacteriological position had been studied the pollution would have been described as serious from that point of view.

Similarly, small amounts of organic matter, innocuous from a public health point of view, found their way into the Great Berg during the dry summer months. Again the chemical analyses and the bottom animals indicated a pollution so mild that it could be looked upon as fertilization; but, because of the slow flow in the river, the high temperature and the small algal and aquatic plant growth, aeration was very poor and the small amount of organic matter seriously depleted the dissolved oxygen. This was very evident in some of the larger pools where fish were seen in distress or were even killed at times.

Experience in Europe has shown that the mildest fertilization of rivers has to be regarded as a serious pollution danger, for, when the water runs into lakes or is stored in open reservoirs, heavy algal blooms may appear. In this way the usefulness of the water for domestic or industrial purposes can be greatly impaired.

No organic contamination, therefore, can be dismissed as mere fertilization until it is certain that this will not impair any of the uses the community is making of the water. In this paper all forms of organic contamination are considered to be pollution because of the actual or potential limitations they place on the use of the river water.

In the following descriptions of the effects of pollution on the fauna, only the main trends are dealt with. It is realized, however, that many changes which seem at present of minor importance may be found significant after more cases of pollution have been studied; because of this, further details are given in the appendixes at the end of this part.

The author would like to thank Professor J. H. Day and Dr. G. J. Stander for assistance and guidance, Dr. K. M. F. Scott for assistance in the field and laboratory, and Messrs. J. F. Elsworth and E. J. Smith, who did the water analyses. The work was financed by the South African Council for Scientific and Industrial Research and was carried out in the laboratories of the Departments of Zoology and Chemistry at the University of Cape Town.

Methods: The biological and chemical methods used are described in Part 1.

1. MILD ORGANIC POLLUTION OF THE GREAT BERG RIVER IN THE PAARL-WELLINGTON DISTRICT (Figures 12 and 13)

This section of the river has been fully described on page 140 of Part 1 under Sub-zone IIIB, the Foot-hill, Stony Run Zone. It consists of a series of slow-flowing, sandy pools with intervening stony runs and stickles. In some places there are stony or sandy beaches while in others the banks are overgrown with grass (*Paspalum vaginatum*) or fringed by palmiet (*Prionium serratum*).

A. Sources of Pollution

1. At the time of the survey most of Paarl was provided with sewers and only a few factories discharged organic wastes directly into the river. The largest discharge came from a fruit and vegetable canning factory during spring when the river flow usually provided adequate dilution. Minor discharges from this factory, from a winery and a distillery occurred throughout the year, but, on the whole, factory discharges were low during December to April when the river flow was small.

2. During the wet season the storm-water drains at Paarl carried much organic matter and street refuse into the river.

3. The Paarl sewage works was not a serious source of pollution. Domestic sewage was partially treated in trickle filters and, after settling, was allowed to run into a marsh alongside the river. During the dry season it was absorbed there, and during heavy rains, when varying amounts were carried into the river, it was well diluted. Raw industrial effluent was run into pans, most of which were near the sewage works, though a few were higher up the river in Paarl itself. During the dry season a slow seepage from these pans found its way into the river, but, as it ran a long way through sandy soil, it was not a serious source of pollution. Winter rains would have carried some of this straight into the river, but it would have been greatly diluted.

4. Faecal matter and other rubbish, deposited along the banks and on dry portions of the bed during the dry season, were swept into the river by the first good rains. The effects of this pollution would have been masked by 2 above.

B. The effects of pollution on water quality (Table 64)

Table 64 lists only those analyses which indicate pollution, water taken during other months was normal (Table 7). For the sake of comparison records are given for two unpolluted stations (No. 10 which is above Paarl and No. 13 which is well below Wellington) as well as the two polluted stations (No. 11 at the Paarl sewage works and No. 12 at Wellington).

Unfortunately the programme had to be limited during the dry season of November 1952 to March 1953 when samples were taken at only one unpolluted station (No. 10) and one polluted station (No. 12).

TABLE 64. WATER ANALYSES FROM WELLINGTON, GREAT BERG RIVER

	Station	1951 May	August	October	1952 January	March	April	May	June	November	1953 January	February	March
Flow, acre-feet	12	81,382	60,220	52,131	898	2,134	2,840	27,295	11,779	11,953	458	64	586
Ammonia nitrogen, p.p.m. N	10	0.000	0.006	0.008	0.000	0.038	0.006	0.018	0.060	0.034	0.028	0.008	0.022
	11	0.007	0.216	0.016	0.196	0.236	0.070	0.066	0.086	—	—	—	—
	12	0.060	—	0.066	0.086	0.056	0.142	0.082	0.133	0.050	0.060	0.064	0.068
	13	0.022	0.036	0.056	0.006	0.072	0.003	0.056	0.083	—	—	—	—
Albuminoid nitrogen, p.p.m. N	10	—	0.068	0.036	0.054	0.070	0.044	0.066	0.086	0.080	0.084	0.094	0.034
	11	—	0.280	0.028	0.112	0.220	0.080	0.096	0.108	—	—	—	—
	12	—	—	0.050	0.094	0.302	0.094	0.145	0.159	0.116	0.146	0.318	0.180
	13	—	—	0.064	0.060	0.130	0.067	0.074	0.080	—	—	—	—
Nitrate nitrogen, p.p.m. N	10	0.00	0.36	0.10	0.15	0.19	0.10	0.10	0.05	0.06	0.07	0.09	0.09
	11	0.00	0.63	0.37	0.44	0.11	0.12	—	0.05	—	—	—	—
	12	0.39	—	0.16	0.49	0.26	0.17	0.11	0.12	0.18	0.03	0.13	0.12
	13	0.57	0.25	0.50	0.08	0.13	0.10	0.13	0.13	—	—	—	—
Oxygen, % saturation	10	96	—	100	93	100	92	92	97	89	100	95	94
	11	92	90	100	88	89	84	88	82	—	—	—	—
	12	—	—	96	79	0	84	86	79	88	86	68	72
	13	—	—	86	89	86	91	86	87	—	—	—	—
B.O.D., p.p.m.	10	1.31	—	1.92	0.20	1.50	0.50	0.40	0.70	1.10	1.60	1.20	0.80
	11	2.99	5.7	3.74	0.30	2.60	—	1.00	0.50	—	—	—	—
	12	—	—	2.87	1.80	—	0.80	3.00	0.50	1.30	2.80	5.75	2.00
	13	—	—	1.24	1.57	1.40	1.20	0.80	0.80	—	—	—	—
4-hour O.A., p.p.m.	10	1.60	—	1.20	0.45	0.99	1.20	2.00	1.26	3.48	1.21	0.91	1.15
	11	1.80	—	1.20	0.70	1.73	1.79	1.97	1.37	—	—	—	—
	12	4.50	—	1.30	0.90	4.81	1.90	2.55	1.67	4.14	1.92	3.74	2.40
	13	—	—	1.40	0.88	2.56	1.68	1.69	3.29	—	—	—	—

Table 64. Only values for months during which pollution was detected are shown. During the rest, values were normal (see Part 1, Tables 7, 12 and 13)

From Table 64 it is apparent that the figures for saline ammonia, albuminoid nitrogen and nitrate merely hint at pollution on a few occasions. Rises in the Biochemical Oxygen Demand were more significant; in February 1953, a high B.O.D. was accompanied by a marked drop in the dissolved oxygen; in March 1952, the oxygen dropped to nil in a slow-flowing pool at Station 12. The B.O.D. was not measured on this occasion. It should be noted that all the analyses were from spot samples as no continuous sampling apparatus was available.

During the dry season high 4-hour oxygen absorption values were associated with rises in the B.O.D., but increases during the wet season did not correlate with B.O.D. values and were probably due to run-off from farm land carrying mud and humus into the river.

Wet-season pollution, the origin of which is discussed in A 2, 3 and 4, was detected by increases in ammonia, albuminoid nitrogen and B.O.D. values at Station 11 in August 1951, by increases in albuminoid nitrogen, B.O.D. and 4-hour O.A. at Station 12 in May 1952, and finally by the same sort of data at Stations 11 and 12 in June 1952. Unfortunately no samples were taken at the height of a flood when the effects of pollution under A 2 should have been most apparent. The samples for August 1951 were taken when a flood was receding.

Pollution was detected during the dry months of 1951 to 1952 by the following bracketed changes:

January 1952 at Station 11 (ammonia).

March 1952 at Station 11 (ammonia, albuminoid nitrogen, B.O.D.).

at Station 12 (albuminoid nitrogen, 4-hour O.A. and dissolved oxygen).

at Station 13 (albuminoid nitrogen and 4-hour O.A.).

April 1952 at Station 12 (ammonia and B.O.D.).

The zero value for dissolved oxygen at Station 12 in March was probably due to the fact that the sample was taken in a long, and almost still, pool. Fish near by were swimming at the surface, obviously in distress.

During the dry season of 1952-3 pollution was again detectable by the following bracketed changes:

January 1953, very mild pollution at Station 12 (albuminoid nitrogen and B.O.D.).

February 1953 at Station 12, the position worse with very slow flow (albuminoid nitrogen, 4-hour O.A., B.O.D., dissolved oxygen).

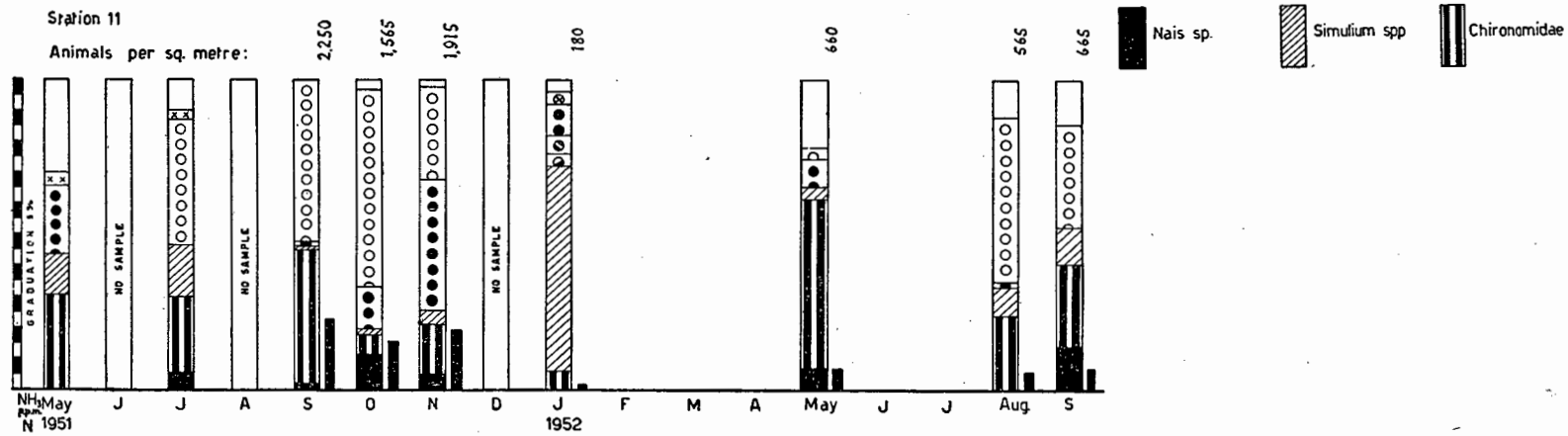
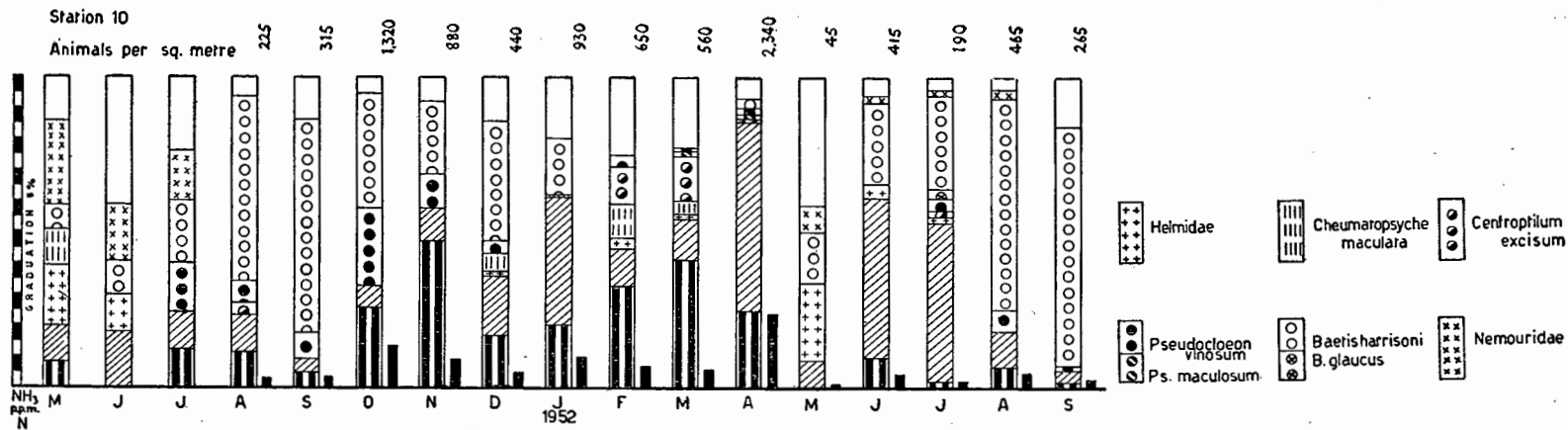
March 1953 at Station 12, conditions improved with stronger flow (albuminoid nitrogen, dissolved oxygen and B.O.D.).

In April all signs of pollution disappeared with an early beginning to the winter rains.

C. Effects on the Fauna

(i) *Stony runs and stickles*

Figure 12 shows the percentage composition and density of the fauna, month by month, for three stations whose water analyses have just been discussed above.



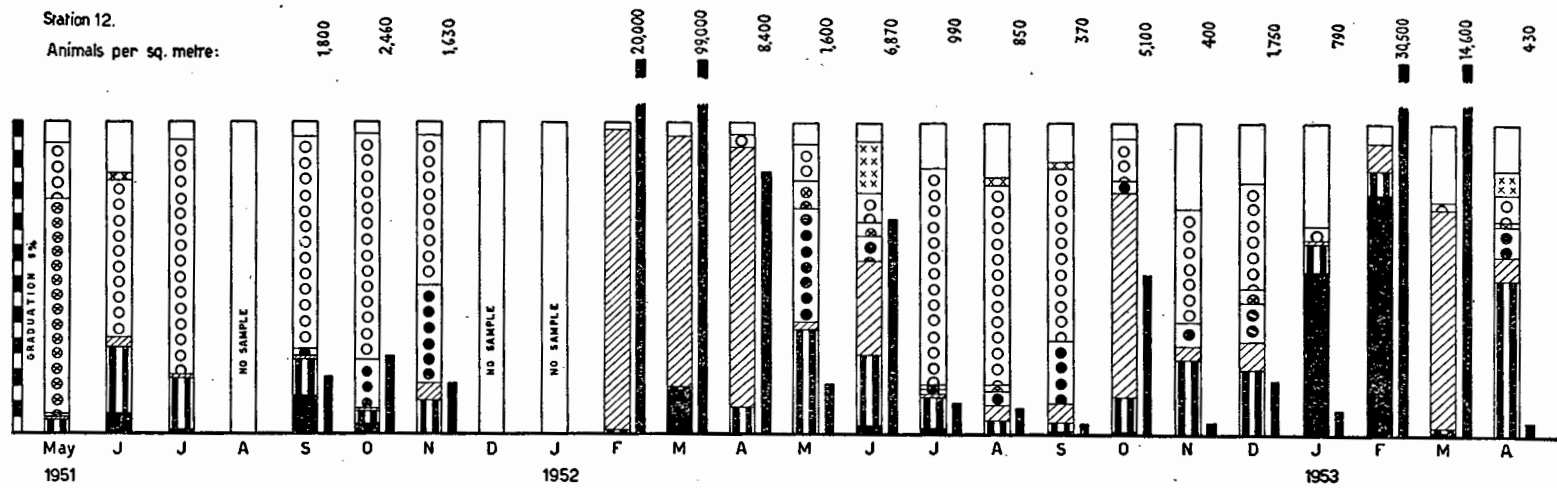


FIG. 12. Changes in the fauna of stony runs and stickles brought about by pollution. Station 10 was unpolluted and Stations 11 and 12 polluted. Each broad column represents the monthly percentage composition of the fauna in symbols explained opposite, the blank spaces at the top of the columns represent the species not shown; most of these had very small percentage incidences in the samples. The 5 per cent graduations at the side are to give some idea of the incidences represented by the column segments. The narrow black columns indicate the density of the total fauna, as determined by the Surbur sampler, the actual figures are given above each column.

Station 10, above Paarl, was unpolluted while Stations 11 and 12 at Paarl sewage works and Wellington, respectively, were polluted. It may be noted that the records for Station 11 were incomplete as the stony runs there were often dry in summer and deeply submerged in winter.

Wet Season Pollution (May to September) (see A 2, 3 and 4 above): During the wet months the stones at Station 10 were clean while those at Stations 11 and 12 were usually slimy with a little mud underneath. The range of current speeds among the stones is given in Table 2. As shown in figure 12 the main effects of pollution were a general increase in the density of the fauna, involving several species normally present such as *Baetis harrisoni*, fairly regular increases in the incidence and density of green chironomid larvae (mainly Orthoclaadiinae) and the appearance of a new element, *Nais* sp., not found in the normal fauna. The few samples taken at Station 11 during these months suggest that pollution was more serious there than lower down at Station 12 where some recovery had taken place. Further details are given in Appendix 1(a)(i).

Dry Season Pollution (December to March) (see A 1 above): During the dry months the stones at Station 10 remained clean but those at Stations 11 and 12 were thinly covered with fine mud. At Station 12 they were also partially overgrown by filamentous algae, such as *Spirogyra*, especially in 1953. As water-levels rose in March the newly submerged parts of the stones at 11 and 12 were slimy, but in April 1953 stones at Station 12 were fairly clean.

The drop in river flow led to reduced current speeds among the stones which have to be taken into account when considering the fauna. A general picture can be obtained from Tables 1 and 2, but conditions on the actual day of sampling are given below:

Month	Maximum daily flow (recorded near Station 12 on days of sampling)	Current speeds among stones	
		Station 10	Station 12
1952			
January	10 cusecs	—	—
February	2.4 cusecs	—	—
March	15 cusecs	50-65 cm./sec.	87 cm./sec.
1953			
January	4.2 cusecs	—	62 cm./sec.
February	1.0 cusec	—	30-48 cm./sec.
March	25 cusecs (only 5 cusecs 3 days before)	—	95 cm./sec.

With slow flow and warm water the slight amount of organic matter produced profound changes in the fauna among the stones, as is evident from figure 12. To

begin with, there were large increases in the density of the fauna due largely to outbursts of *Simulium* and *Nais*. Though not shown on figure 12 there were also large growths of *Plumatella* sp. and increases of the mollusc *Ferrissia* sp. at Station 12 during February and March 1952 and again in January and February of 1953. On the other hand there was a reduction of Baetidae, particularly during February when the river was at its lowest.

The general effect of this mild pollution was to produce a biological enrichment with growths of microplankton which supported the large colonies of *Simulium* and *Plumatella*. Such changes might be expected in a zone of recovery; conditions would have been more serious at the actual sites where the effluents entered the river, but these were limited in extent and were not investigated. For further details see Appendix 1(a)(ii).

(ii) *Fauna of Marginal Vegetation* (fig. 13)

Figure 13 gives the monthly percentage composition of the fauna of the two unpolluted stations (10 and 13) and two polluted stations (11 and 12) already described in Part 1B. Unfortunately no method of quantitative sampling has been developed for the type of marginal vegetation encountered here.

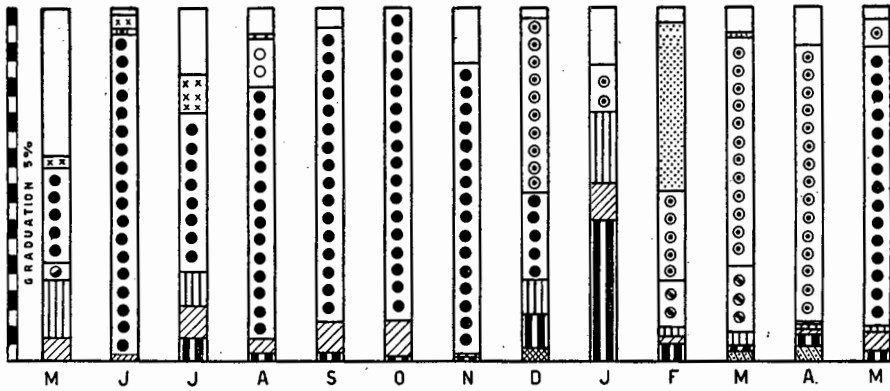
Wet Season Pollution (May to September): When comparing the monthly percentage incidences in figure 13 it should be borne in mind that flooding and current strength have a marked effect on this type of habitat, and reference should be made to Table 1. Heavy rains had started before samples were taken in May 1951, they reached a maximum in June and July and tailed off in September and October. In 1952 heavy rains did not fall until the end of July. During floods the marginal vegetation was violently disturbed at all four stations, but during interflood periods that at Station 12 was bathed by slower currents than the vegetation at the other stations.

During the wet season the submerged vegetation at Station 11 was coated with a brown slime which clogged the net, especially in June and July; it was not noticed at other stations. Samples from Station 11 showed large numbers of *Nais* sp., an increase in the number of green chironomid larvae and even a few larvae of the sewage fly, *Psychoda alternata*. On the other hand there was a lower incidence of Nemouridae, Baetidae, *Simulium* spp. and *Pseudagrion* sp. At Station 12, in the zone of recovery, *Nais* sp. decreased and finally disappeared at Station 13. Green chironomid larvae were still abundant at Station 12 and only decreased at Station 13.

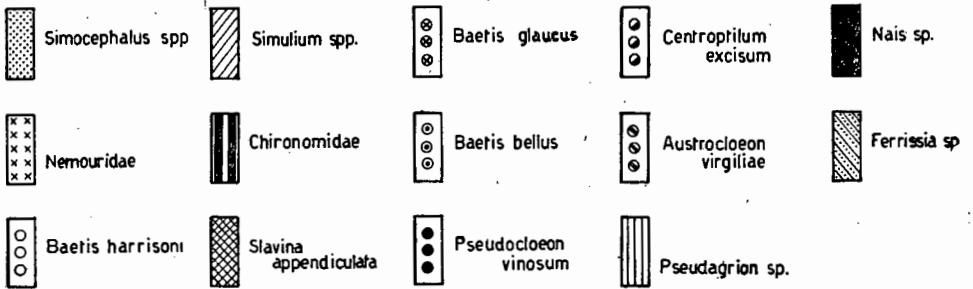
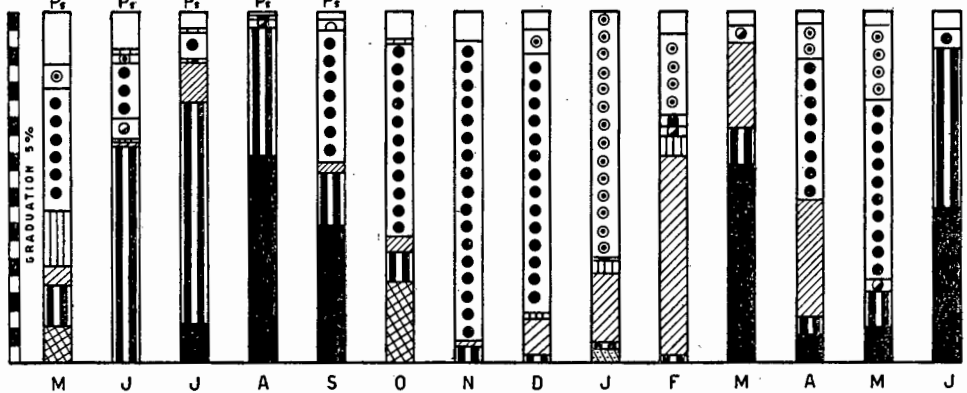
Though the composition of the fauna was more normal at Station 12, the general density was much higher than at the unpolluted stations. No quantitative samples were taken but this was obvious from the bulk of animals in the hand-net samples.

Dry Season Pollution (December to March): During the dry season flow conditions in the marginal vegetation were not the same at all stations. At Stations 10 and 12 the vegetation sampled fringed wide, deep pools where the flow was barely detectable, especially in February. Here Cladocera were able to develop, especially *Simocephalus* spp. At Stations 11 and 13 the vegetation was always bathed in a steady current of about 30 cm./sec. or over. This should be borne in mind when comparing the faunas.

STATION 10 Cecilia's Drift



STATION 11 Daljosaphat



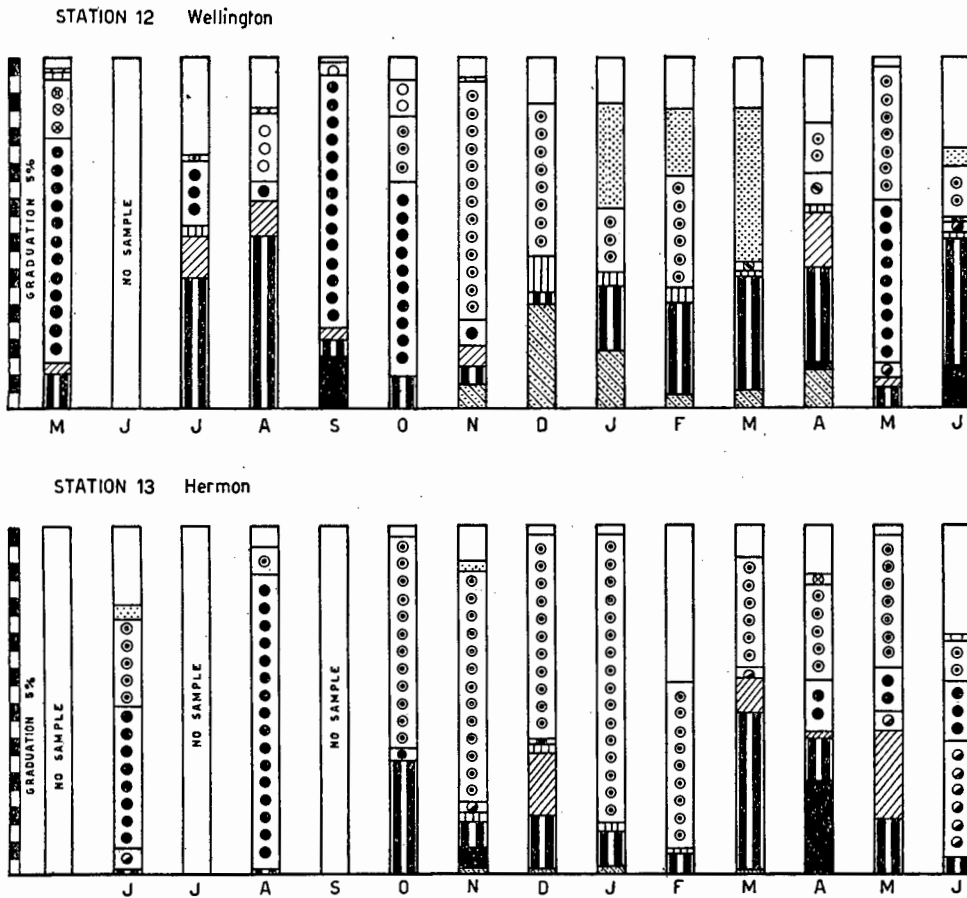


FIG. 13. Fauna in submerged marginal vegetation. Station 10, unpolluted; Stations 11 and 12, polluted; Station 13, practically recovered. Each column represents monthly percentage composition of the fauna with symbols explained opposite. Blank spaces at the top of columns represent a residuum of species with very small percentage incidences. 5 per cent graduations on the left give some idea of the percentages represented by the different segments. The very large blank space at the top of the column for February at Station 13 was mainly due to *Austrocaenis* sp. Ps: *Psychoda alternata* present in small numbers. The months shown are May 1951, to June 1952.

Rather unexpectedly the mild dry season pollution had less effect on the fauna of the marginal vegetation than on that of the runs and stickles; it seemed that the fairly high biochemical oxygen demand would have depleted the dissolved oxygen in the quiet water among the vegetation to a much greater extent. (Note the low value at Station 12 discussed in section B, above). It was possible, however, that this effect was counteracted by epiphytic algae producing oxygen on the spot.

Though the faunal differences between the stations during December, January and February (fig. 13) can be largely attributed to different current speeds, pollution

in the slow section at Station 12 resulted in increases in water snails, Cladocera and Chironomidae, and a drop in Baetidae, while at Station 11, with a steady flow, it led to increases in the incidence of *Simulium* spp. When the river freshened in March 1952, the pollution effects at Station 11 were similar to those seen during the wet season.

A note of warning was struck by the large numbers of *Nais* sp. at Station 13 in April. This may have resulted from some local pollution, but it may mean that outbursts in this habitat do not always indicate organic pollution.

For further details see Appendix 1(b).

2. ORGANIC POLLUTION OF THE DWARS RIVER, GROOT DRAKENSTEIN (Tables 65 and 66 and figure 14)

The Dwars River is an important tributary of the upper Great Berg River in Zone IIIA, and it also runs through a heavily cultivated fruit-farming region. Before it reaches the pollution zone its fauna is much the same as that of Zone IIIA of the Great Berg (Part 1, Section F).

There are three main sources of contamination of this stream:

1. Agriculture. During the rainy season there is much run-off from orchards and vineyards which contains organic matter and possibly residues from chemical sprays.
2. Domestic pollution. The village of Pniel lies right on the banks of the Dwars (see fig. 2). Sanitary conditions were rather primitive and pollution must have occurred during all seasons. However, the actual amount of organic matter entering the river would have been small.
3. Industrial pollution. There is a large fruit and vegetable canning and jam factory at Groot Drakenstein which had no disposal plant at this time, and an attempt was being made to treat the effluents by running them on to land. However, places could be seen where effluents containing organic matter had been running into the river, though this did not happen during the occasional short visit. This pollution seemed to be taking place mainly in late summer and autumn.

No attempt was made to separate the effects of the different types of pollution, but it was considered that No. 3 was the most serious.

An idea of conditions in this part of the river in the early 1930s can be gained from a report by A. C. Harrison (1934) to the Cape Piscatorial Society. At that time the Dwars was a good trout stream down to its junction with the Great Berg; in fact, the 'Junction Pool' (Station 8) was a very popular fishing-spot. This is no longer the case. Some of A. C. Harrison's main observations on the fauna of the Dwars are given in column 1 of Table 65 where they can be compared with the conditions at the time of this survey as well as with those at Station 5 on the main river. It is considered that, before deterioration set in, the fauna at Station 7 on the Dwars was much the same as at Station 5 on the main river. This contention is supported by A. C. Harrison's report and by the strong similarities between the fauna at Station 5 and Station 6 on

a near-by tributary, the Wemmer, which is still unpolluted and a popular trout stream. The only factor which might have produced differences in the Dwars is the shading here and there by large exotic trees, mainly oaks, poplars and acacias, but the study of the shaded Assegaaibos stream described in Part 2, Section B 1, suggests that this would have been very limited in its effects.

TABLE 65. A COMPARISON OF BOTTOM FAUNA RECORDS, A. C. HARRISON, 1934, AND THE 1950-1952 SURVEY

ORGANISM	1934	1950-1952	
	DWARS	DWARS Station 7	GREAT BERG Station 5
Small Planarians	Plentiful.	Common.	Few.
Nemouridae	Very numerous.	Few, even in season.	Plentiful in season.
<i>Aprionyx peterseni</i>	Present.	None found.	Present.
<i>Castanophlebia calida</i>	Very plentiful.	Very few.	Few.
<i>Choroterpes nigrescens</i>	Present.	None found.	Present.
<i>Lithogloea</i> spp.	Appeared to be very common.	Few.	Plentiful in season (spring) and present at most times.
<i>Afronurus harrisoni</i>	Present.	None found.	Present.
<i>Petrothrincus circularis</i>	Very common.	None found.	Present.
Leptoceridae	Common.	A few in July.	Common.
<i>Cheumatopsyche maculata</i>	Present.	None found.	Common.
<i>Chimarra ambulans</i>	Present.	None found.	Present.
<i>Myspoleo agilis</i>	Plentiful.	None found.	Plentiful.
<i>Chloroniella peringueyi</i>	Present.	None found.	Present.
Blepharoceridae	'A feature.'	None found.	Common in winter and spring.
<i>Ferrissia</i> sp.	Not reported.	A few found.	None found.

Samples were taken at the road bridge at Groot Drakenstein, Station 7, and the fauna was sampled in stony runs and stickles with a hand-net of 23 mesh to the inch grit gauze.

Table 66 gives the relevant results of the chemical analyses. Unfortunately a continuous water sampler was not available and only spot samples were taken, none of them while factory pollution was actually taking place.

Conditions of the bottom. In February 1951 and in January, March and April 1952, the stones were coated with brown, slimy deposits, and in February 1951 there were also strong growths of *Spirogyra*, with the associated caddis, *Hydroptila capensis*. At all times there was a certain amount of black mud under the stones and much leaf and twig detritus between them. No current speeds were available but conditions were much the same as at Station 5.

In figure 14 (p. 321) the fauna of the runs and stickles is compared with that at Station 5 during the same months; from these it will be seen that pollution affected the fauna at Station 7 throughout the year and that it produced two distinct types of change. There were those organisms which benefited, especially green chironomid larvae and *Nais* sp., and, to a lesser degree, *Lumbriculus* in September and Lumbricidae in January and March (not shown on figure 14). Most significant were the few larvae of the sewage fly, *Psychoda alternata*, which appeared during winter and spring months.

In contrast there were many organisms which could not tolerate the pollution, such as the caddis *Cheumatopsyche maculata* (see fig. 14), *Myspoleo agilis* and *Oecetis modesta*, the last two are not shown on figure 14 but were common or at least present at Station 5 during most of the year. Others were the Nemouridae, Helmidæ and most of the may-flies such as *Afronurus harrisoni* and species of *Lithogloea*; the Leptophlebiidae were only represented at Station 7 by an occasional *Castanophlebia calida* whereas this and other species were found regularly at Station 5 (see Table 16).

Quantitative samples were not taken but the bulk of the animals in the qualitative samples indicated that the density of the fauna was much the same at the two stations except in March and April 1952, when it was very low in the Dwars.

These results from the Dwars suggest the changes to be expected in any upper river zone in the Western Province when organic pollutants are introduced. The main one here was the disappearance, or reduction in numbers, of species typical of clean upper reaches. This type of change was not so apparent in the Great Berg lower down at Paarl as species typical of lower zones seem to be more resistant to mild pollution. The organisms which benefited from the pollution were much the same as found elsewhere.

TABLE 66. ANALYSES OF DWARS RIVER WATER

	1950			1951				1952		
	Sept.	Nov.	Dec.	Feb.	July	Sept.	Nov.	Jan.	March	April
pH		6.5	6.3	6.4	6.2	6.3	6.7	6.4	6.3	6.6
Total dissolved solids, p.p.m. .	60	63	56	80	38	37	36	42	47	47
Turbidity as p.p.m. SiO ₂	1.5	0.0	8.0	0.0	5.0	3.0	3.0	5.0	0.5	1.5
NH ₃ N. as p.p.m. N.	0.030	0.010	0.034	0.000	0.008	0.000	0.000	0.000	0.010	0.024
Albuminoid nitrogen as p.p.m. N						0.008	0.044	0.048	0.003	0.054
Nitrate as p.p.m. N	0.01	0.30	0.01	0.32	0.15	0.03	0.05	0.14	0.08	0.06
Dissolved oxygen, % saturation			97		97	94	96	84	88	87
5-day biochemical oxygen demand, p.p.m.			1.16		0.90	0.50	1.45	1.70	0.60	0.80
4-hour O.A. from KMnO ₄ , p.p.m.					1.10	0.98	0.75	0.60	1.19	1.23

3. MILD TO HEAVY ORGANIC POLLUTION IN THE KROM STREAM, STELLENBOSCH (Tables 67 and 68, figures 15, 16 and 17)

This small stream was chosen for study as it was subject to serious organic pollution just before it joined the Eerste River, below Stellenbosch. It is not the purpose of this section to give a comprehensive account of its ecology but enough information to demonstrate the effects of pollution.

As the map, figure 15, shows, there are two main arms to the stream system, the longer, the Plankenbrug stream, drains the north-western slopes of the Simonsberg and the hills to the north of Stellenbosch, and the shorter, the upper Krom, runs down Ida's Valley and drains the southern and western slopes of the Simonsberg and hills to the east of Stellenbosch. This branch also receives a few small tributaries from the northern slopes of the Jonkershoek range.

Both streams run through farm lands, the Plankenbrug through orchards, vineyards and mixed farms, and the upper Krom through orchards and vineyards. Both dry up during the late summer in their lower reaches but this is mainly because their water is used for irrigation.

The water in these streams contains more mineral matter than that of the upper Great Berg (Tables 5, 6 and 7) because, while the latter receives most of its run-off from Table Mountain sandstone formations, their water comes from formations which contain more soluble minerals. Only the peaks of the Simonsberg and the Jonkershoek range are composed of Table Mountain sandstone while the lower slopes are of decomposed granite and most of the hills around Stellenbosch have soils derived from the Malmesbury System (see Part 1, Section J(1)(b)—Geology of Drainage Basin).

Tables 67 and 68 give the results of the analyses from the two source streams and from the polluted parts of the lower Krom. During February and part of March, when the source streams were dry, the flow was kept up at Station 4 by water from the town furrow which carried surplus irrigation water, originally from the Eerste River, with a lower concentration of dissolved solids. Some of this water, from another furrow, kept up an intermittent trickle at Station 2.

A. Sources of Pollution

Water analyses from Station 1, just over a mile above the town, showed no obvious signs of pollution (Table 67). Occasional high 4-hour O.A. figures were associated with a high mud content. Results from the upper Krom taken at the railway bridge just before confluence were similar. In the lower parts of the Krom serious pollution enters from the following sources:

1. Storm-water drains from the town. These carried down a lot of street rubbish during the rainy season. However, most of the town had water-borne sewage and the effluent from the works did not find its way into the Krom.
2. The town's system of irrigation furrows. Water was taken from the Eerste River and run through open furrows over a large section of the town to be used by residents for their gardens. Much remained unused, however, even in summer, and found its way into the Krom. On the way the water picked up organic matter which formed a serious source of pollution at Stations 2 and 4 where furrows discharged into the Krom.
3. Distillery effluents. The distilleries at Station 4 operated from the end of January to the end of May, and their effluent of wine slops had a very high

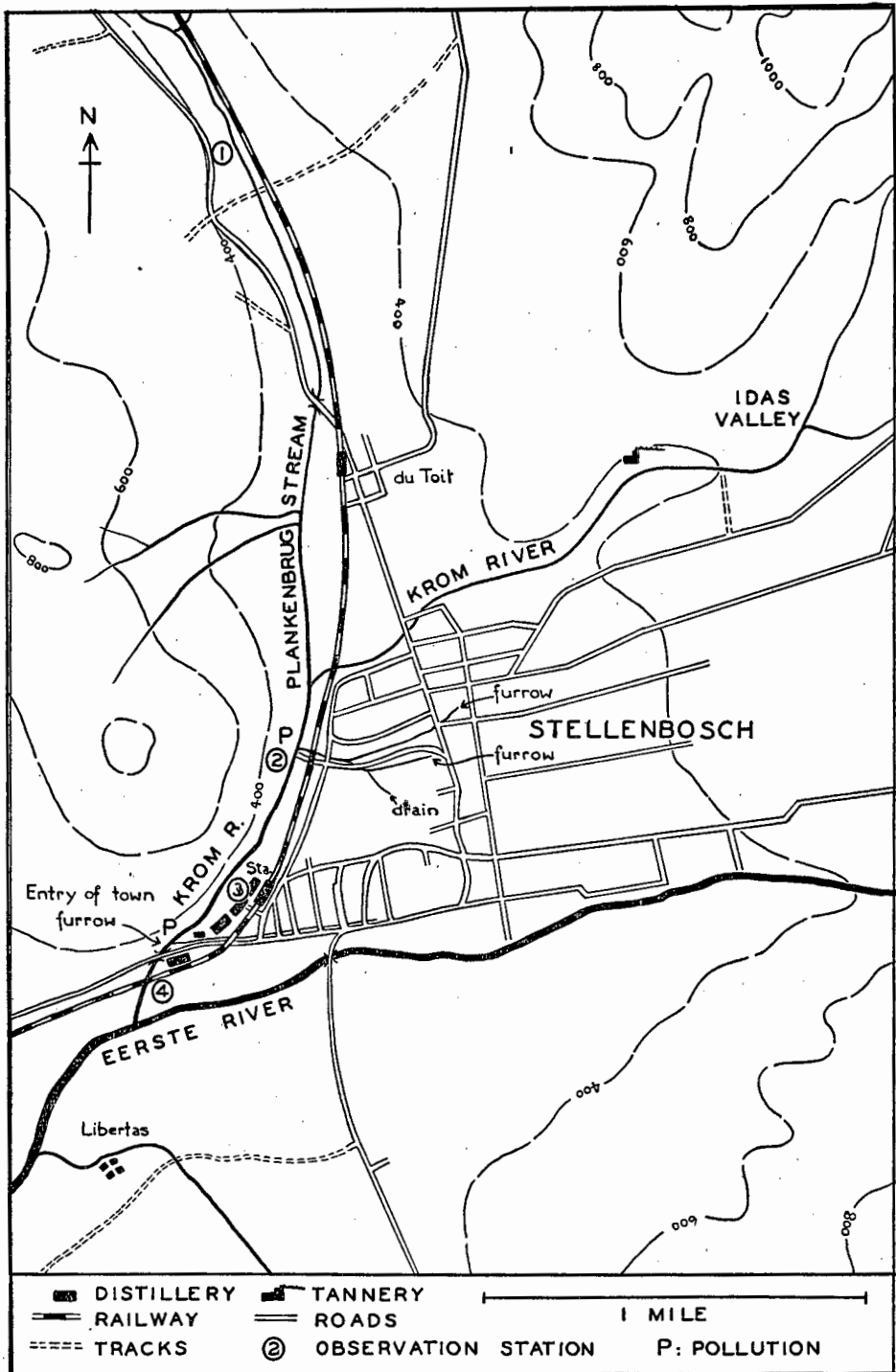


FIG. 15. Map of Krom River and Plankenbrug Stream.

organic content. During the period of this survey attempts were made to dispose of the effluent by irrigation, but the available land was insufficient and much ran into the Krom, especially by early March. Early autumn rains in March made the position worse by washing effluents into the stream.

B. Description of Stations

Station 1: This was just over a mile above Stellenbosch on the Plankenbrug stream where it had cut itself a deep bed into the clayey soil and was floored with coarse sand, gravel and patches of stones. The bed was shaded by pines, poplars and other trees. During rainy periods the stream came down in flood, but at other times it flowed fairly quietly and was dry during February and most of March. Samples of the fauna of stones in the current were taken.

Station 2. The stream here ran through a series of sandy pools and stony runs and stickles, the bed was heavily shaded by oaks, poplars, acacias and other exotic trees, and was broad enough to accommodate normal winter floods fairly easily. Samples were taken from stones in runs and stickles.

Station 3. This was similar to Station 2 in all important respects, and sampling was soon discontinued there.

Station 4. This was at the old road bridge, since replaced by a new one below the railway line. It was similar to Station 2 but there was a clearing in the trees and marginal vegetation appeared, mainly the grass *Paspalum vaginatum*, but also some Cyperaceae. Samples were taken in the small stony runs and stickles and in the submerged marginal vegetation.

Normal Conditions above the Sites of Pollution

Table 67 shows that the B.O.D. did not rise significantly and that high 4-hour O.A. figures were associated with high turbidities due to mud. Otherwise the water was normal except for one comparatively high nitrate in the upper Krom in April which could have been due to run-off from farm lands. There was a tannery in Ida's Valley, but this did not seem to pollute the upper Krom.

The fauna was sampled at Station 1 in June 1952 and then monthly from August to January 1953, after which the stream dried up. The flow resumed in March but no further samples were taken. Figure 17 shows that the fauna was composed mainly of *Simulium* larvae, green chironomid larvae and *Baetis harrisoni*. The June fauna is not shown but was much the same as that in August.

The upper Krom was not sampled regularly, but, from the few samples taken, the fauna appeared to be similar. For further information see Appendix 2(a)(i).

The Effects of Pollution

Water Quality (Table 68)

Though there were definite signs of organic pollution at both lower stations, conditions were worse at Station 4. When sampling began in April 1952 the first light rains of the season had fallen and, as always after rain, there was much paper, street

TABLE 67. WATER ANALYSES FROM PLANKENBRUG STREAM (STATION 1) AND UPPER KROM

	1952 April	May	June	July	August	September	October	November	December	1953 January	March	April	
pH	7.5	8.4	7.4	7.3	7.4	7.0	7.4	7.5 7.4	7.1 7.2	6.5	6.3	7.1	Station 1 Upper Krom
Total dissolved solids p.p.m.	188.8	237.0	216.2	256.2	296.0	297.0	297.0	233.8 154.0	212.4 248.2	412.0	304.8	192.8	Station 1 Upper Krom
Chlorides p.p.m.	74.0	81.6	76.0	99.0	109.0	74.0	115.0	88.0 40.0	89.0 84.0	191.0	33.0	46.0	Station 1 Upper Krom
Total alkalinity as CaCO ₃ , p.p.m.	49.0	34.8	37.0	32.0	34.8	37.0	51.0	42.0 39.0	38.0 54.0	49.0	36.0	42.0	Station 1 Upper Krom
Turbidity as SiO ₂ p.p.m.	9.0	10.0	4.8	12.1	31.0	28.0	33.0	25.3 22.3	18.0 3.3	1.5	3.00	65.5	Station 1 Upper Krom
Ammonia nitrogen as p.p.m. N	0.007	0.032	0.059	0.016	0.042	0.072	0.067	0.016 0.017	0.022 0.046	0.022	0.140	0.054	Station 1 Upper Krom
Albuminoid nitrogen as p.p.m. N	0.078	0.108	0.108	0.070	0.164	0.380	0.220	0.130 0.156	0.088 0.098	0.072	0.750	0.054	Station 1 Upper Krom
Nitrate as p.p.m. N	0.11	0.10	0.03	0.14	0.13	0.17	0.17	0.24 0.09	0.13 0.53	0.08	0.09	0.65	Station 1 Upper Krom
Dissolved Oxygen p.p.m.	9.0	11.0	11.4	11.0	9.2	8.2	8.3	7.9	8.3	6.1		9.0	Station 1 Upper Krom
Dissolved oxygen % saturation	87	100	100	91	86	78	84	89	92	66		86	Station 1 Upper Krom
5-day Biochemical Oxy- gen Demand p.p.m.	0.80	1.00	0.8	0.3	0.6	1.9	0.8	1.8	2.2	1.9		1.6	Station 1 Upper Krom
4-hour O.A. from KMnO ₄ , p.p.m.	2.68	3.41	2.28	1.52	4.25	11.31	5.03	2.11 3.57	1.81 2.02	1.11	21.93	9.22	Station 1 Upper Krom
3-minute O.A. from KMnO ₄ , p.p.m.	0.89	0.95	0.63	0.61	1.25	3.33	1.76	0.80 1.16	0.91 0.91	0.40	6.56	2.35	Station 1 Upper Krom

TABLE 68. WATER ANALYSES FROM KROM, STATIONS 2 AND 4

	Station	1952											1953			
		April	May	June	July	August	September	October	November	December	January	February	March	April		
pH	2	7.7	7.2	7.3	7.3	7.4	7.2	7.5	7.4	6.8	6.8	6.7	6.6	6.8		
	4	7.1	7.0	7.2	6.3	7.1	7.3	7.4	7.4	7.1	7.0	6.5	4.8	6.8		
Total dissolved solids	2	212.4	177.6	204.8	218.8	266.2	285.2	260.0	213.8	296.2	206.2	96.8	333.8	257.4		
p.p.m.	4	103.2	144.8	120.2	198.4	241.2	265.2	200.4	208.6	164.8	306.0	77.8	427.4	259.2		
Chlorides, p.p.m.	2	78.0	71.0	68.0	78.0	92.6	62.0	89.0	77.0	115.0	85.0	32.0	83.0	75.0		
	4	25.0	46.6	39.0	47.0	82.0	65.0	68.0	73.0	59.0	116.0	18.0	37.0	74.0		
Total alkalinity as	2	50.0	35.6	43.0	48.0	36.0	37.0	42.0	39.0	47.0	29.0	17.0	34.0	35.0		
CaCO ₃ , p.p.m.	4	17.0	23.0	24.0	24.0	36.0	33.0	34.0	38.0	29.0	59.0	27.0	nil	37.0		
Total acidity, p.p.m.	4												100			
Turbidity as p.p.m.	2	3.5	30.8	19.5	18.5	28.0	28.5	26.8	13.8	90	2.0	10.3	263.0	42.0		
SiO ₂	4	22.0	17.8	26.3	11.6	25.8	32.5	30.3	8.8	7.3	3.0	2.3	185.0	37.5		
Ammonia nitrogen as	2	0.026	0.032	0.104	0.078	0.060	0.306	0.082	0.050	0.278	0.030	0.042	0.310	0.110		
p.p.m. N	4	0.012	0.007	0.050	0.216	0.076	0.000	0.110	0.022	0.026	0.024	0.020	0.800	0.074		
Albuminoid nitrogen	2	0.110	0.123	0.150	0.100	0.179	0.418	0.190	0.142	0.248	0.096	0.186	0.430	0.188		
p.p.m. N	4	0.132	0.090	0.166	0.690	0.179	0.500	0.190	0.127	0.108	0.104	0.116	1.420	0.248		
Nitrate nitrogen as	2	0.21	0.12	0.08	0.09	0.27	0.23	0.25	0.32	0.63	0.24	0.08	0.70	0.83		
p.p.m. N	4	0.11	0.13	0.07	0.18	0.19	0.18	0.25	0.85	0.39	0.26	0.08	0.17	0.86		
Dissolved Oxygen	2	10.30	9.10	10.1	11.0	9.4	8.2	8.7	8.0	7.3	7.7	5.3	5.2	9.0		
p.p.m.	4	7.4	7.8	9.1	9.0	8.6	8.4	8.6	7.7	8.4	6.9	4.6	2.0	7.6		
Dissolved oxygen %	2	100	88	95	95	88	78	88	88	80	87	60	56	88		
saturation	4	76	76	90	80	81	80	87	85	94	77	53	22	74		
Biochemical oxygen	2	1.90	1.60	1.20	0.90	0.80	5.60	0.80	1.70	3.10	1.80	>5.30	>5.20	4.20		
demand, p.p.m.	4	>7.40	>7.80	2.10	>9.00	6.25	5.40	3.70	1.60	3.10	5.30	3.80	>2.00	>7.60		
4-hour O.A. from	2	2.41	3.86	2.78	1.52	3.95	9.60	3.72	2.21	4.04	1.22	2.73	11.68	8.20		
KMnO ₄ , p.p.m.	4	5.84	4.30	3.29	10.61	3.80	10.40	3.42	2.26	1.71	1.41	1.92	49.18	8.80		
3-minute O.A. from	2	0.76	1.01	0.88	0.40	1.10	2.88	1.16	0.75	1.31	0.51	0.11	3.59	2.25		
KMnO ₄ , p.p.m.	4	1.40	1.14	0.76	4.24	1.20	2.83	1.16	0.65	0.71	0.61	0.51	9.53	2.46		

rubbish and some mineral oil in evidence. During the whole wet season B.O.D. values were high at Station 4 but not at Station 2 except in September.

During the dry months (November to February) polluted furrow water raised the B.O.D. at both stations and, in February, some distillery waste was running in just above Station 4. Early rains in March produced a much more serious condition as much town rubbish was brought down as well as so much distillery waste that it could be smelled in the water at Station 4. Here the acidity rose and free tartaric-citric acid was detected; the low B.O.D. figure shown was due to the low dissolved oxygen and the water was not aerated before storing for five days. Though heavy rains had fallen before the April samples were taken, the stream bed had not been cleaned out.

It will be noted from Tables 67 and 68 that B.O.D. and 4-hour O.A. values did not always rise and fall together. High turbidities during rainy periods sometimes sent up the 4-hour O.A. but had little or no effect on the B.O.D. (see Station 2 in August and October). Ammonia and nitrate values were always low but rose a little when pollution was heavy.

It should be borne in mind that all analyses were carried out on single spot samples. Continuous sampling apparatus would have shown fluctuations in pollution intensity and especially the peak periods with the first flood waters after dry intervals.

Effects on the Fauna

(i) *Runs and Sticks* (figure 16): While the stones at Station 1 were always clean, at the polluted stations they were usually slimy to the touch. From December to April at Station 4 there were short algal growths on the stones and, during February, March and April, there was a small amount of *Sphaerotilis*-like growth. None of the growths was identified.

Sampling was carried out initially with a hand-net of 23 mesh to the inch grit gauze but later quantitative samples were taken with a Surbur sampler with the same grit gauze.

There were good rains during the months of August to October and the flow was always strong with occasional floods. Organic pollution, mainly from storm water, led to increases in the incidence of Chironomidae (mainly green Orthoclaadiinae) and the appearance of small numbers of *Nais* sp. as well as *Tubifex* sp., *Lumbriculus* sp. and Lumbricidae. The last three were more in evidence at Station 4 where the pollution was more severe. There was a marked drop in the incidence of *Simulium* spp. at the polluted stations (Appendix 2(a)(iii)).

During November and December the rainy season tailed off, little storm water entered and the stream level dropped. The resulting quieter and steady flow conditions allowed the development of large numbers of *Nais* sp. and green chironomid larvae (see Station 4, where quantitative samples were taken).

January at Station 4 saw the start of a more serious pollution from the town furrow and conditions were worse in February, probably because distillery wastes began to flow in. All this led to an increase in the density and incidence of the larger Oligochaeta and to a decrease of the normal fauna such as *Baetis harrisoni*, *Simulium* spp.

and Chironomidae. When the serious distillery pollution began in March practically all the normal fauna was eliminated, their incidence was too low to show on figure 16, and the dominance by the larger Oligochaeta was virtually complete.

It was interesting to find that *Nais* sp., so characteristic of milder pollution, virtually disappeared when the pollution became heavy.

The following changes at Stations 2 and 4 are considered also to have been due to pollution: the appearance of *Platycyclops* sp. and *Psychoda alternata*, and increases in the numbers of planarians, nematodes and the mollusc *Ferrissia* sp. In general the density of the fauna was higher at the polluted stations than would be expected in a normal stream (cf. conditions at Station 10 on the Great Berg, fig. 12). Further details are given in Appendix 2(a)(i)-(vi).

(ii) *Marginal Vegetation*, Station 4 (figure 17): Sampling began in the *Paspalum* and Cyperaceae in October with a hand-net of 23 mesh to the inch grit gauze, but from December to April 58 mesh to the inch grit gauze (No. 3) was used.

The composition of the fauna is given in figure 17 and should be compared with that at Station 10 on the Great Berg River which can be taken as fairly typical for an unpolluted stream in the district (fig. 13).

In October 1952, current speeds among marginal vegetation were strong and there was a small amount of brown slime on all surfaces. Pollution effects were: the presence of *Nais* sp., the high incidence of green chironomid larvae and the presence of a few Lumbricidae and *Psychoda alternata*. Also significant were the small numbers of the Baetid nymphs usually associated with this type of habitat, for instance, the incidence of *Baetis bellus* was only 1.0% and of *Pseudocloeon vinosum* only 0.4%. The presence of *Baetis harrisoni* was probably due to the high current speeds.

During November and December the pollution was milder but current speeds fell and there was a lot of brown slime which clogged the net. *Nais* sp. and green chironomid larvae still dominated the fauna and *Simulium* larvae disappeared. The normal fauna was represented by a very few *Baetis bellus* and one or two *Pseudagrion* nymphs. On the whole the fauna appeared denser than normal though no accurate comparisons can be given.

In January the fauna was more normal, but pollution was indicated by the presence of *Nais* sp. and Lumbricidae, and the high incidences of the molluscs *Ferrissia* sp. (30%) and *Lymnaea* (*Ps.*) *columella* (6.5%). The fauna was not exceptionally dense.

The more serious pollution in February was accompanied by the disappearance of Baetidae and green chironomid larvae and by a very low incidence of *Pseudagrion* nymphs. Pollution was indicated by the presence of *Nais* sp., *Platycyclops* sp. and Lumbricidae, and by the high incidences of *Ferrissia* sp., *Lymnaea* (*Ps.*) *columella* (6.0%), planarians and nematodes. There was much brown slime among the vegetation and a little filamentous algae. There was a small outburst of Cladocera, mainly *Leydigia* sp. and *Ilyocryptus* sp., but this was probably due to the quiet conditions among the vegetation and in spite of the pollution rather than because of it.

The onset of heavy pollution in March resulted in the almost total disappearance of the normal constituents of the fauna as well as some of those characteristic of mild

FIG. 16

Symbols for Figs. 16, 14 and 17

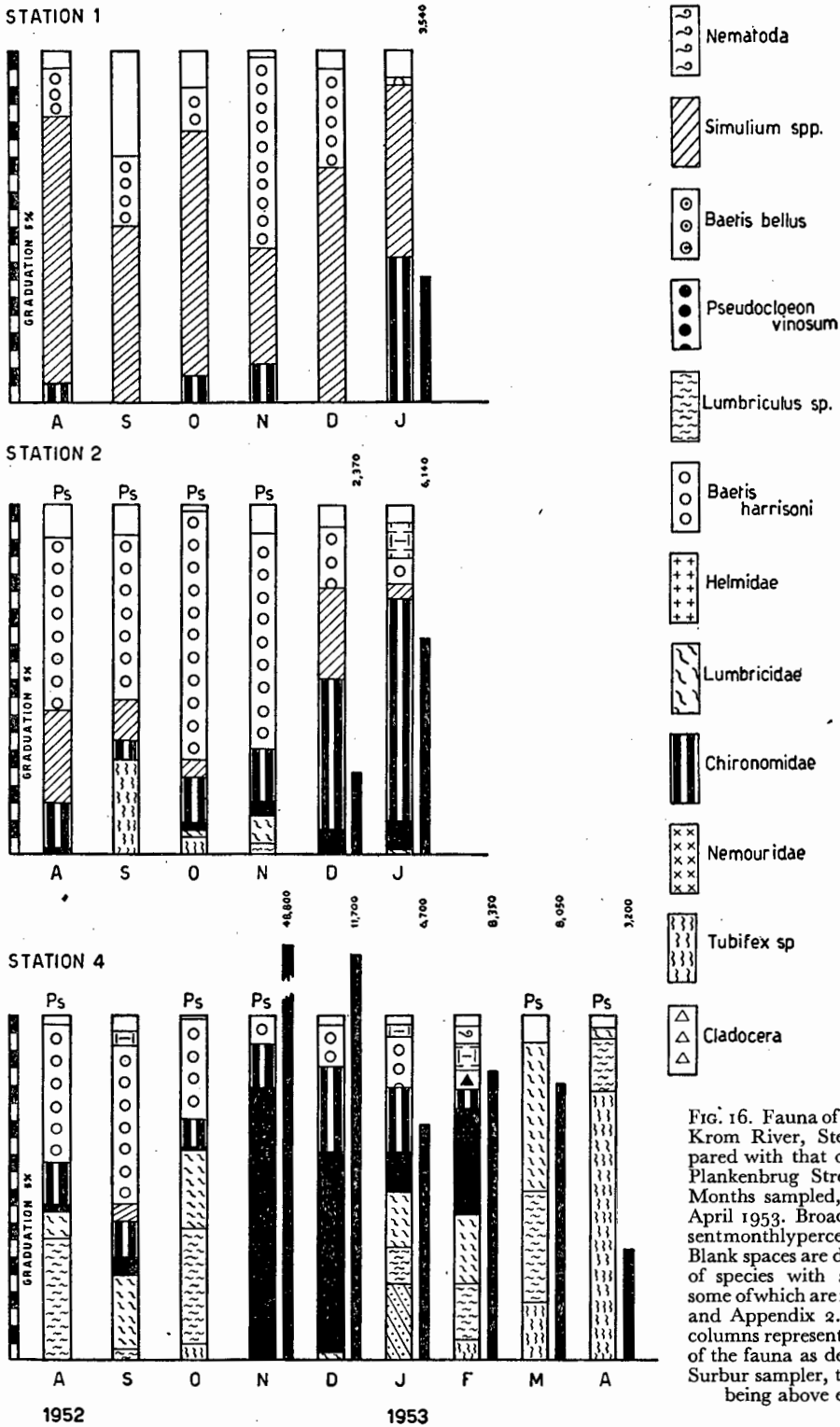
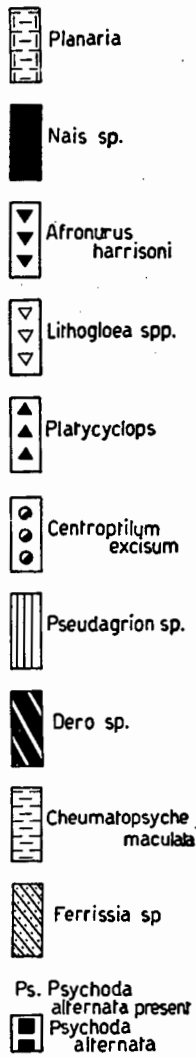


FIG. 16. Fauna of stones in current, Krom River, Stellenbosch, compared with that of the unpolluted Plankenbrug Stream (Station 1). Months sampled, August 1952, to April 1953. Broad columns represent monthly percentage incidences. Blank spaces are due to a residuum of species with small incidences some of which are mentioned in text and Appendix 2. Narrow, black columns represent the total density of the fauna as determined by the Surbur sampler, the actual figures being above each column.



Above: Great Berg River Station 5
 Below: Dwars River

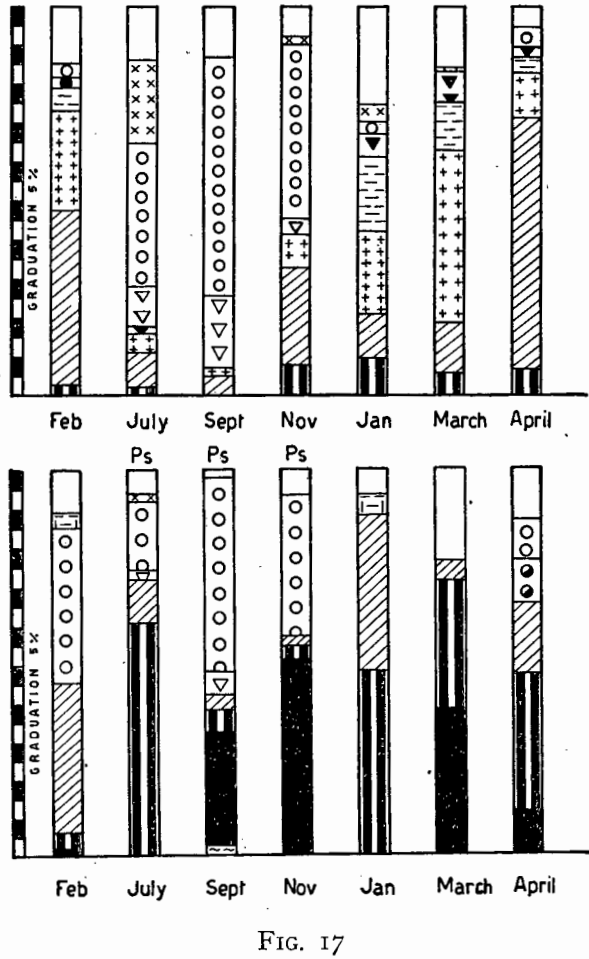
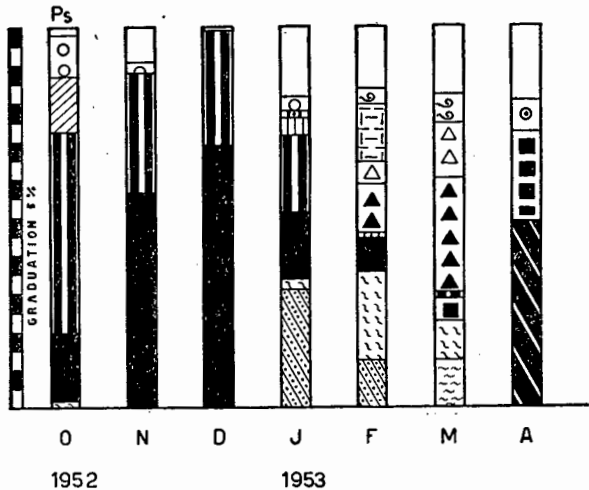


FIG. 17

FIG. 14. Below, fauna of stones in the current in the Dwars River, February 1951 to April 1952. Above, the fauna for the same months and habitat at Station 5 on the Great Berg, for comparison. Columns represent monthly percentage composition and blank spaces are due to a residuum of species with small incidences some of which are mentioned in the text.

FIG. 17. Fauna of marginal vegetation at Station 4 on the Krom. Months sampled: October 1952 to April 1953. Columns represent monthly percentage incidence. The blank spaces represent a residuum of species with small incidences some of which are mentioned in the text and Appendix 2.



pollution. Among the former were the Baetidae, *Pseudagrion* nymphs and green chironomid larvae, and the latter were *Nais* sp. (0.1%) and *Ferrissia* sp. (0.7%). On the other hand there were numbers of *Lumbriculus* sp. and Lumbricidae living in deposits of brown slime on the lower parts of submerged vegetation and associated with them were *Platycyclops* sp., *Psychoda alternata*, red *Chironomus* larvae and small nematodes (Rhabditidae). The snail *Lymnaea columella* had an abnormally high incidence (5.0%). On parts of the submerged vegetation near the surface there were thick growths of filamentous algae among which were living Cladocera and *Cyclops* sp. (see Appendix 2, b). The fauna was not abnormally dense.

The scouring floods in April, mentioned above, swept away nearly all the March fauna and there were very few animals in the sample. Survivors were the larvae of *Psychoda alternata*, and *Lymnaea columella* (8.0%). A few *Dero* sp. (Naididae) appeared and *Baetis bellus* began to re-establish itself.

DISCUSSION

The foregoing studies were made as a contribution to the building up of a picture of the effects of organic pollution on South African streams and rivers. The water-courses chosen were of a type very common in South Africa, that is, fast-flowing streams with beds broken up into a series of pools and rapids or runs and stickles, and subject to scouring floods and great seasonal fluctuations of flow.

Studies on the fauna were limited to the larger bottom animals, and Protozoa were not considered. Unfortunately algae also had to be neglected but it is hoped that this omission will be remedied in future studies.

(a) *The effects of mild pollution*

The effects of adding relatively small proportions of organic contaminants were studied on the Paarl and Wellington section of the Great Berg and in the Dwars at Groot Drakenstein. The former pollution was barely detectable chemically, except by the 5-day, Biochemical Oxygen Demand test, and the latter was not detected by chemical means at all as it was probably too intermittent.

Mild pollution of this nature may produce biological changes by means of the following:

1. The introduction of food material. The polluting matter either acts as food itself or produces bacterial or algal growths which are eaten by various constituents of the fauna. This would lead to increases in certain species while new types of food would encourage species not normally abundant or even present.
2. The fouling of the surfaces of stones and submerged vegetation. With mild pollution this is not usually due to polluting materials themselves but to the induced growths mentioned above, often mixed with varying amounts of trapped mud. This fouling discourages many species characteristic of the normal fauna but encourages others, some not normally found.

3. The reduction of dissolved oxygen. With mild pollution this would only occur during the dry season when flow is slow, and then only in quiet pools and backwaters where there is little aquatic vegetation or algae. Under such conditions very little organic matter can cause drastic drops in the dissolved oxygen, especially where large numbers of fish have been concentrated in pools because of the drop in river-level.

Effects on the fauna

These could be termed 'indicator effects' and vary a great deal depending on current speeds, degree of pollution, temperature range, nature of substratum sampled, etc. Only a few general remarks can be made here.

Fauna of Runs and Stickles: Negative effects. Species typical of mountain streams or the upper zones of rivers appeared to be very sensitive and either disappeared entirely or were greatly reduced in numbers (for these see Part I, Section F 3). Specially sensitive were caddis, which usually disappeared entirely. With increasing fouling of surfaces *Simulium* spp. and Baetidae became fewer or disappeared.

Positive effects: Mild pollution encouraged Chironomidae (green Orthoclaudiinae and Chironominae) and *Baetis harrisoni* when the flow was fairly strong. Lymnaeidae increased when there were no floods to wash them away. Enormous growths of *Simulium* spp. were encountered at Wellington during the dry season when the flow was low and large amounts of plankton had developed in the pools between the runs; at this time surfaces of the stones were not slimy. It is considered that large outbursts of *Simulium* are more to be expected at some distance from the source of pollution, even when the pollution is mild, as large amounts of microplankton must have time to develop to support them. New elements which appeared with the mild pollution were *Nais* sp., at various times, and *Plumatella* sp., during the dry season.

Marginal Vegetation: Negative effects. Baetidae were reduced in numbers or eliminated, especially those typical of this habitat, *Pseudocloeon vinosum* and *Baetis bellus*, and similarly with *Pseudagrion* sp. Nouridae (Plecoptera) appeared to be adversely affected, though not much information is available as the stations sampled were at the bottom of their range.

Positive effects. Green Chironomid larvae increased when there was a fairly strong flow among the vegetation. There was some increase in *Simocephalus* spp. during the dry season in sheltered spots. Lymnaeidae also increased in sheltered places when there were no floods to wash them out. *Nais* sp. was the principal new element to appear and *Psychoda alternata* appeared in small numbers during the wet season.

(b) *The effects of serious pollution*

As the pollution becomes more serious the Biochemical Oxygen Demand overtakes the aeration rate and the dissolved oxygen saturation is reduced below normal, even in fast-flowing streams. There may be direct fouling of surfaces and induced growths of bacteria, 'sewage fungus' (*Sphaerotilis* etc.) and algae become so thick that interstices between stones in runs and in marginal vegetation become blocked.

Serious organic pollution produces changes in the following ways:

1. By the introduction of large amounts of food material, either the polluting materials themselves or the bacterial or algal growths induced by them.
2. By the fouling of surfaces. This becomes progressively more serious as the pollution increases and makes many surfaces uninhabitable for certain species but provides shelter for others.
3. By reducing dissolved oxygen concentrations. Species disappear as their minimum requirements are no longer available.
4. By introducing toxic substances. These may either be introduced with the polluting effluents or result from their breakdown in the stream.

Effects on the Fauna

In general, the indicator effects of progressively more serious pollution were the total elimination of the normal elements of the fauna, and even the reduction in number or elimination of species which benefit from mild pollution, and the introduction of a new fauna of specialized forms. There was also usually an increase in the total biomass, mainly because of the high density of larger Oligochaeta.

Fauna of Stony Runs and Sticks: Negative effects. Those species which benefit from mild pollution, such as green chironomid larvae and *Baetis harrisoni*, may hold their own or even continue to increase as pollution becomes more serious. However, when surfaces become badly fouled and the dissolved oxygen begins to fall, they decrease and finally disappear. *Nais* sp., which appears with mild pollution, also decreases as oxygen concentrations fall and finally disappears.

Positive effects. Increasing amounts of organic matter and growths between and under the stones encourage numbers of Tubificidae and Lumbricidae which finally dominate the fauna. *Psychoda alternata*, red larvae of the *Chironomus plumosus* type and *Platycyclops* sp. also appear. During the surveys the oxygen level did not fall low enough to affect any of these.

Fauna of Marginal Vegetation: Negative effects. Those organisms which benefit initially from a mild pollution are reduced as it becomes more severe. They include green chironomid larvae, *Ferrissia* sp. (Lymnaeidae), *Nais* sp. and other Naididae.

Positive effects. The following appear and replace the normal fauna: small nematodes, *Tubifex* sp., *Lumbriculus* sp., Lumbricidae, *Psychoda alternata* and possibly other species, red larvae of the *Chironomus plumosus*-type, and *Platycyclops* sp. Surface algal growths may shelter a few Cladocera and *Cyclops* spp.

(c) *Indicator animals for fast-flowing streams and rivers*

The term 'indicator animal' is taken to refer to a species which appears with pollution but is not found or is rare in unpolluted streams. However, it is obvious that any pollution indicator will not only be found in polluted waters but will also have a natural habitat somewhere; it is only because the pollution reproduces to some extent

conditions found in the natural habitat, that it is able to appear. For instance, the large Oligochaeta which appear in large numbers in stony runs and stickles during heavy organic pollution, are normally found in bottom muds in quiet stretches. The heavy fouling of the stones provides suitable shelter for them, and suitable food. Similarly, *Nais* sp. is normally found in eutrophic ponds and lakes where it finds suitable food; mild organic pollution of streams and rivers provides it with similar food not usually found in running water.

It is therefore necessary to state in what type of stream or on what type of bottom an animal can be considered to indicate pollution. Also, the density is important; for instance, a few *Tubifex* sp. in a fast-flowing stony run or stickle might indicate organic pollution, but not on a muddy bottom; however, on a muddy bottom a high density would indicate organic pollution.

Bearing these things in mind it is considered that for fast-flowing streams and rivers, such as the Great Berg and the Krom, the following are pollution indicators:

- (i) Indicators of mild organic pollution: *Nais* sp. when present as more than 5% of the total fauna in net samples, and *Psychoda alternata* when present at all.
- (ii) Indicators of serious organic pollution: *Tubifex* sp., *Lumbriculus* sp. and Lumbricidae when present in large numbers. Also important are *Psychoda alternata*, *Platycyclops* sp. and larvae of the *Chironomus plumosus* type.

However, it is considered that changes in communities, as described above, are far more important indications of pollution than the presence of individual 'indicator species'.

(d) *Comparison with conditions reported from Europe and the United States*

It is not easy to draw direct comparisons between the effects of organic pollution in rivers and streams in Europe and the United States and those in South Africa. Apart from obvious differences in the species present in the different countries, there is the difficulty that the types of streams studied are also different.

Polluted streams and rivers described by Butcher (1946), Huet (1949) and Liebmann (1951) are comparatively slow flowing and quite unlike the Great Berg and Krom with their stony beds and great fluctuations in flow. However, there are similarities in the faunal changes.

The effects of heavy organic pollution seem to be much the same everywhere, that is, the almost total elimination of the normal fauna and its replacement by a new association mainly of larger Oligochaeta, including *Tubifex* spp., red *Chironomus* larvae and numerous ciliate protozoa. In slow-flowing streams direct air breathers such as *Eristalis* larvae, Culecidae and pulmonate snails commonly occur. Heavy pollution in the Krom produced similar conditions except that the Oligochaete association was different and the usual air-breathing forms were not there because of the fast current. However, *Psychoda alternata*, an air-breathing dipterous larva, occurred; it would seem to prefer conditions of rapid flow as it is common in trickle

filters at sewage works all over the world. An interesting absentee from European and American descriptions (see Gaufin and Tarzwell, 1956) is the copepod *Platycyclops* sp. (genus *Platycyclops* G. O. Sars), which occurred in the Krom and is common in polluted waters and sewage works effluents in many parts of South Africa.

Most workers report definite clean-water associations of fauna which are upset by even mild organic pollution and which are re-established at the end of a recovery zone after all traces of organic pollution have disappeared. Liebmann and Huet in Europe, and Gaufin and Tarzwell in the United States, among others, report that Ephemeroptera and Trichoptera are characteristic clean-water groups, which was also found to be the case during these studies. Gaufin and Tarzwell also report that Plecoptera (stones flies) and Helmidæ ('riffle beetles') are also very sensitive to pollution, which also agrees with the above findings, especially those from the Dwars River.

Though mild pollution in the Great Berg upset clean-water associations, certain constituents of the fauna persisted or even benefited; this is also reported from other parts, Huet, Liebmann and Gaufin and Tarzwell report increases in aquatic snails, and Huet reports increases in Orthocladinae. The prominence of *Baetis harrisoni* in zones of mild pollution is paralleled somewhat by the occurrence of *Cloeon dipterum* (Liebmann, 1951) and *Callibaetis* sp. (Gaufin and Tarzwell) in recovery zones. Gaufin and Tarzwell report that *Simulium vittatum* is a more tolerant species which was also the case with some South African *Simulium* (e.g. *Simulium adersi*, *S. ruficorne* and *S. nigratarsis*), and that *Cheumatopsyche* sp. was more resistant to organic pollution than other caddis, which also applied to *Cheumatopsyche maculata* in the Great Berg (see Appendix 1(a)(ii)).

(e) *Pollution effects encountered and the 'Saprobic Zones'*

When comparing conditions found in the Great Berg and Krom with those in other countries one comes up against the 'Saprobic System' of estimating pollution. This was first put forward by Kolkwitz and Marsson but recently it has been revised and fully redescribed by Liebmann (1951) who has developed it into a practical system of determining water quality in rivers and lakes now used by the Bayerische Biologische Versuchsanstalt, Munich. Both the original system and later developments set out to classify organically polluted waters according to the chemical and biological conditions found in them with a strong emphasis on the biological studies.

According to the Saprobic System the zone of heavy organic pollution is the polysaprobic zone where there is actually decomposing organic matter and little or no dissolved oxygen. The alpha and beta mesosaprobic zones are regions of progressive improvement where organic matter is broken down and breakdown products, such as free ammonia, ammonium salts and nitrates, are removed by biological action. The final stage, where the natural water has rid itself of all injurious matter, is the oligosaprobic zone. Liebmann (1955) now uses the term 'quality classes' ('Güteklassen'), classes I, II, III and IV are equivalent to the oligo-, alpha and beta meso- and polysaprobic zones respectively. All stages may not be present in any one case

of pollution as small amounts of pollutants would only produce a mesosaprobic stage initially.

The biological recognition of the saprobic zones or 'Gütenklassen' is based on a study of the bacteria, fungi, algae, protozoa, invertebrates and fish present. Certain organisms have been found to be valuable as indicator species but usually the whole association of organisms is considered.

When considering the value of this system, as worked out in Europe, in South Africa it must be realized that European workers are describing associations to be found in streams and rivers with a comparatively slow and steady flow, conditions which are hardly to be found in South Africa at all. Under conditions of rapid or torrential flow many typical polysaprobic organisms would be swept away and physical aeration would be so vigorous that heavy organic pollution would not necessarily be accompanied by anaerobic conditions. Nevertheless pollution zones studied in the Great Berg and Krom showed certain strong similarities to those of the saprobic system (see (d) above).

It was interesting to find that even a cursory examination of a slow-flowing polluted stream near Cape Town revealed conditions very similar to those described by European workers. The Black River receives a large volume of effluent from a sewage works and polysaprobic conditions occur with the characteristic fauna of *Tubifex* sp., red *Chironomus* larvae, *Eristalis* larvae, and abundant ciliates.

It would seem, therefore, that some such system could be worked out in South Africa but that dangers of over-simplification would have to be avoided. Factors that would have to be taken into account would be: the type of stream (fast-flowing, slow-flowing, etc.), the river zone in which the pollution occurs, and the type of organic pollution (sewage, industrial or mixed). Biological associations in the pollution zones would be different in the different climatic regions of the country, but it is considered that the factor of climate is not so important as the stream type.

APPENDIX I

FURTHER INFORMATION ON POLLUTION CHANGES IN THE GREAT BERG RIVER

(a) STONES IN CURRENT

(i) Wet season: The drop in Nemouridae at Stations 11 and 12 may have been due to the pollution or possibly merely to increasing silt loads. In June 1952, when there was practically no rain and the water was clear, Nemouridae were numerous at Station 12. The species of *Simulium* common at Stations 11 and 12 were *S. unicornutum*, *S. medusaeformis* and *S. ruficorne*.

(ii) Dry season: *Prostoma* sp. Numbers were higher than normal at Station 12 in January 1953 (90/sq. m., 11.4% incidence), February (486/sq. m., 1.6% incidence), and March (410/sq. m., 2.8% incidence). *Ferrissia* sp. From being practically absent at Station 10 it became common at Station 12 in February 1952 (108/sq. m., 0.5% incidence), March 1952 (144/sq. m., 0.2% incidence), January 1953 (126/sq. m., 16% incidence), February (459/sq. m., 1.5% incidence), March (151/sq. m., 1.0% incidence).

The difference in the Baetidae in January 1952 (incicated in fig. 12 by circular symbols) was probably mainly due to different current speeds which were slower at Station 11. *Baetis harrisoni* could not tolerate well the combined effects of pollution, high temperature and slow flow during February and March 1953, but there were always a few present. There were always a few *Aeschna minuscula* in the samples from Stations 10, 11 and 12 but they were less common at the lower stations, especially 12. *Cheumatopsyche maculata* was not abundant in this stretch of the river (Table 16). During February and

March 1952, their density was approximately the same at Stations 10 and 12, in 1953 they were not found at Station 12 in January, but were back again in February. *Hydroptila capensis* appeared at Station 12 during February and March 1953, associated with growths of *Spirogyra* sp. (February 120/sq. m., March 2,830/sq. m.).

The Hydraenid beetle, species 8K, was unaccountably exceptionally numerous in March 1952 at Station 12 (240/sq. m.). The dry season outbursts of *Simulium* at Station 12 were mainly of *S. adersi*, though *S. ruficorne* was common and there were a few *S. nigratarsis*. Conditions were not so suitable for *Simulium* spp. in February 1953, as during the previous year because of the slower flow in the river. During February and March 1952, the density of Chironomidae was much the same at Stations 10 and 12; in January 1953, at Station 12, there were very few, 72/sq. m., a high density in February, 2,036/sq. m., and normal numbers in March, 216/sq. m.

(b) MARGINAL VEGETATION

Slavina appendiculata was common in this part of the river during May and October, but its incidence at Station 11 was unusually high.

Pseudagrion spp. The incidence and numbers were reduced at the polluted stations during both wet and dry season pollution.

Lymnaea (Pseudosuccinea) columella. In addition to abnormal numbers of *Ferrissia* sp. at the polluted Station 12 during the dry season, this exotic species was also more abundant there than at Station 10, 3.0% incidence in samples in January, 2.2% in March and 9.1% in April.

APPENDIX 2

FURTHER INFORMATION ON THE KROM, STELLENBOSCH

(a) STONES IN CURRENT

(i) Further information on the normal fauna. Other species practically always present at Station 1 were *Pseudocloeon vinosum*, *Austrocaenis* sp., *Potomon perlatus*, and planarians; *Aeschna minuscula* appeared during the summer months. Lumbricidae and Tubificidae were rare. On the whole the fauna was much the same as at Station 10 on the Great Berg and there were no signs of organic pollution.

A sample was taken in a stony stickle in January in the upper Krom, well above the Ida's Valley farms. The fauna here was dominated by Simuliidae, green chironomid larvae and *Baetis harrisoni*, with a few *Pseudocloeon vinosum*, *Potomon perlatus* and *Cheumatopsyche maculata*. There were also numbers of *Centroptilum sudafricanum* (10% of the total fauna) which were rare in the upper Great Berg where the pH was lower.

(ii) The flow in the main stream at Station 2 ceased during February but there was an intermittent flow coming in from the furrow. Most aquatic animals disappeared except *Ferrissia* sp. and *Lymnaea (Ps.) columella*, which were able to resist the periodic desiccation as the bed was shaded from the sun. Intermittent flow continued through most of March but became permanent again at the end of the month. When the April sample was taken the fauna had not yet been able to re-establish itself but there were a few *Psychoda alternata* which had probably come from the furrow.

(iii) *Simulium* spp. Most identified pupae from the stream were *S. nigratarsis*. They began to diminish at the polluted stations as pollution became more serious; it is possible that they could not attach themselves to the stones, which were slimy or fouled in other ways; it is also possible that their feeding mechanisms were disturbed. They were not present at all at Station 4 in November and December; there were a few in January but they disappeared again in February, March and April.

(iv) *Platycyclops* sp. (genus *Platycyclops* G. O. Sars.). These appeared in the February samples from the stones in the current at Station 4. Its density was probably higher than shown in figure 16 as many individuals were small enough to pass through the meshes of the net. The same applies to the Nematoda. The species encountered was almost certainly that referred to as *Paracyclops poppei* (Rehberg) by other authors.

(v) Further information on the heavy pollution at Station 4 in March. The only insects present among stones were a few red *Chironomus* larvae (28/sq. m.), *Psychoda alternata* (151/sq. m.), *Trithemis* sp. (11/sq. m.), and *Culex* larvae (16/sq. m.). There were also a number of *Simoccephalus vetuloides* and *S. australiensis* (54 and 120/sq. m. respectively) which may have been washed down from above, and a few *Ferrissia* sp. and *Lymnaea columella* (76 and 48/sq. m. respectively). There were a few small nematodes and a number of *Prostoma* sp. appeared for the first and last time during this series of sampling (22/sq. m.).

(vi) The effects of the scouring floods a few days before the April samplings among stones were interesting. Most of the Lumbricidae and *Lumbriculus* sp. were washed out but the numbers of *Tubifex* sp. were little reduced, possibly their longer setae gave them the ability to withstand the stronger currents. Though water conditions had improved, the normal fauna had not had time to reappear.

(b) MARGINAL VEGETATION

The Cladocera present in March 1953 were mainly *Macrothrix* sp. but there were also some *Simocephalus australiensis*, *Leydigia* sp. and *Ilyocryptus* sp. *Cyclops* spp. had a 5% incidence in the sample, and *Prostoma* sp. 7.5%.

This paper is published with the permission of the South African Council for Scientific and Industrial Research.

REFERENCES

- Butcher, R. W. 1946. 'The biological detection of pollution.' *Journ. Inst. Sewage Purif.*, 1946, Part 2, 92-7.
- Gaufin, A. R., and Tarzwell, C. M. 1956. 'Aquatic macro-invertebrate communities as indicators of organic pollution in Lytle Creek.' *Sewage and Industrial Wastes*, 28 (7), 906-24.
- Harrison, A. C. 1934. 'A preliminary report on the Groot Drakenstein trout streams.' Circular No. 21, Cape Piscatorial Society, Cape Town.
- Huet, M. 1949. 'La pollution des eaux, l'analyse biologique des eaux polluées.' Extrait du *Bulletin du Centre Belge d'étude et de documentation de eaux*. Nos. 5 et 6.
- Liebmann, H. 1951. *Handbuch der Frischwasser- und Abwasserbiologie*. Band 1. München.
- 1955. 'Erfahrungen bei der Ausarbeitung des Wassergüteatlases von Bayern.' In *Aktuelle problem inom vattenvården*. Stockholm, 29-40.

ACKNOWLEDGEMENT

The Society acknowledges with thanks the receipt of a substantial grant from the South African Council for Scientific and Industrial Research towards the cost of publication of these four papers.